ISSN 1441-8487

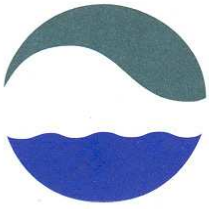
TECHNICAL REPORT SERIES

Number 6

Biological Surveys and Habitat Mapping of Proposed Marine Protected Areas on the Tasmanian North and North-eastern Coasts

Neville Barrett and Simon Wilcox

July 2001



Tasmanian Aquaculture
& Fisheries Institute
University of Tasmania

National Library of Australia Cataloguing-in-Publication Entry

Barrett, Neville Scott, 1962-

Biological Surveys and Habitat Mapping of proposed Marine Protected Areas on the Tasmanian North and North-eastern Coasts

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ISBN 1-86295-028-8.

1. Marine Protected Areas-Tasmania. 2. Habitat Mapping. 3. Conservation-Ecology 4. I. Barrett, Neville, 1962 -. II. Wilcox, Simon, 1972-. III. Tasmanian Aquaculture and Fisheries Institute. IV. Title. (Series: Technical Report Series (Tasmanian Aquaculture and Fisheries Institute) ; no. 6).

597.5609946

Published by the Marine Research Laboratories - Tasmanian Aquaculture and Fisheries Institute, University of Tasmania, 2001

Series Editor - Dr Caleb Gardner

Biological surveys and habitat mapping of proposed marine protected areas on the Tasmanian north and north-eastern coasts

Neville Barrett and Simon Wilcox

Summary

During the summer 1998/99 detailed mapping and biological surveys were undertaken at locations on the northern Tasmanian coastline that had been nominated by commercial and recreational fishers as potential marine protected areas with propagation benefits, or that had been identified during previous studies as potential representative marine protected areas. The fishing industry proposals examined were at Low Head, Lillico Beach and the Three Sisters-Goat Island Nature Reserve on the northern coastline and at Binalong Bay in the north-east. The adequacy of these proposals to provide conservation benefits, including the protection of resident fish stocks was examined, and for some areas, recommendations made on alternative boundary positions to ensure the proposals are effective.

The potential representative areas surveyed were the section of coastline between Rocky Cape and Boat Harbour on the north-west coast, and in the vicinity of Waterhouse Point on the north-east coast. From the results, potential reserve boundaries are suggested that would include examples of the full range of marine habitats present at each of these locations.

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1. Introduction

Changes to coastal marine faunas due to fishing and other human activities have led to increased calls for marine protected areas (MPA's) to be established in both Australia and overseas (Kelleher *et al.* 1995). By 1992, 303 MPA's had been established in Australia (Zann 1995), with differing sizes, management objectives, levels of protection and effectiveness. In Tasmania there are currently four no-take MPA's (called marine reserves), including a large regional reserve at Maria Island, and three small special purpose reserves at Bicheno, Tinderbox and Ninepin Point. The widespread acceptance of these reserves and the benefits they provide has led to the development of proposals for new reserves, from both industry and community groups in addition to government agencies. In a joint initiative in 1997, the Tasmanian Fishing Industry Council (TFIC) and Tasmanian Amateur Sea Fishermen's Association (TASFA) took a leading role in this process by calling for public submissions on the location of potential no-take protected areas that could fulfil a propagation role. This call resulted in the identification of five areas that were acceptable to the key stakeholder groups and these areas were nominated for protection. Given the degree of industry and public support for the proposals it is likely that some or all of the areas will be declared at some stage in the future, contributing to the overall protection of habitats and species in Tasmanian waters. As the proposals are no-take, they will offer a high level of protection for marine communities within them, and will therefore have the potential to provide substantial conservation benefits in addition to their proposed propagation role. The no-take provision means that these areas are category II marine protected areas in the definition of IUCN and the ANZECC task force on marine protected areas (ANZECC, 1999). They are referred to as protected areas in this report to avoid confusion between the terms protected area and propagation area.

To facilitate the further development of these proposals it was considered essential to assess the conservation benefits each proposal had to offer, including their potential to protect stocks of resident fishes. While it was beyond the scope of this study to quantify propagation benefits arising from a particular area, the ability of each area to protect stocks of resident species was assessed with respect to the availability of suitable habitat boundaries. Recent research suggests that distinct habitat boundaries such as a reef/sand interface can restrict the movement of many resident reef species, effectively acting as a boundary fence around protected areas to minimise loss to adjacent fished areas (Barrett 1995, Edgar and Barrett 1999). The choice of an appropriate boundary within, or as the protected area boundary, can therefore minimise the loss of resident species to adjacent fished areas, allowing some stock re-building to occur within the protected area.

A component of this study was aimed at assessing these benefits by examining the range of species and habitats associated with each proposal. The major habitat types in each area were also mapped, so that sufficient information is available to ensure that the boundaries selected will be adequate to achieve the desired conservation outcomes, including protection of resident fish species. The TFIC/TASFA proposed areas that were examined include Binalong Bay, Low Head, Lillico Beach, and the Three Sisters-Goat Island Nature Reserve (Fig. 2). The approximate boundaries of these proposed areas are shown in Figs 4 to 8.

An additional area has been proposed for Bathurst Harbour/Bathurst Channel in Tasmania's south-west, however this area has already been surveyed in some detail and is included within a current Tasmanian Government proposal for a larger reserve in the area. As the proposed areas at Binalong Bay and Three Sisters-Goat Island are of sufficient size to show some recovery following protection, and are likely to proceed given their degree of public support, additional locations outside the proposed boundaries were also surveyed to assess the appropriateness of the proposed boundaries and also to act as control areas for ongoing performance assessment in the years following protection.

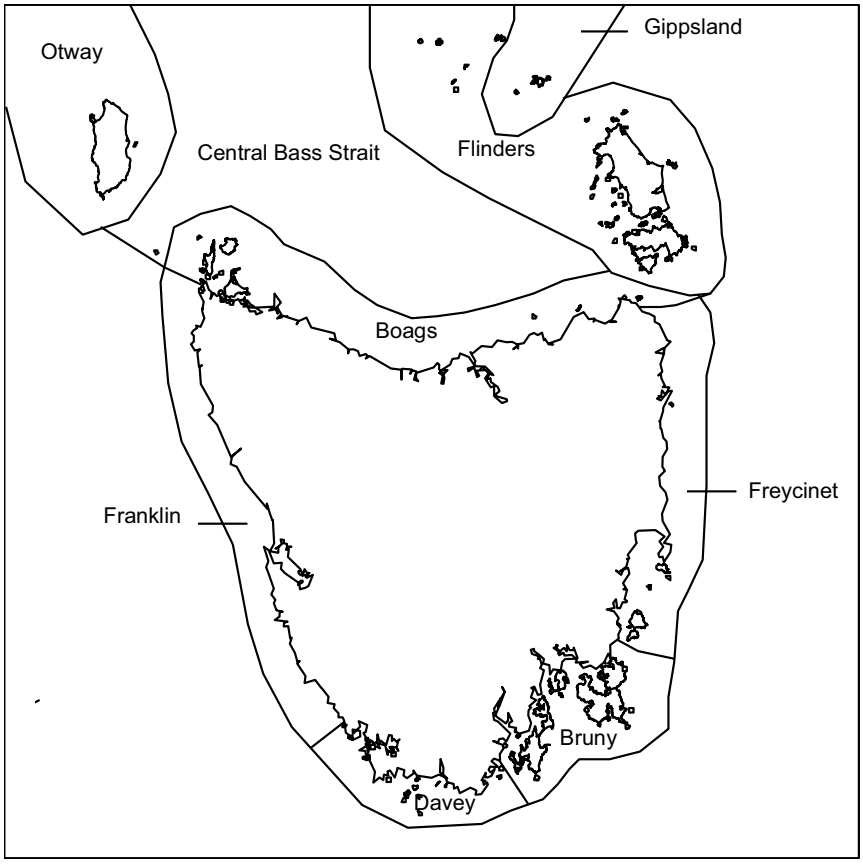

Fig. 1. Major bioregions inferred from reef biota around the Tasmanian coast. (From Edgar *et al.* 1993).

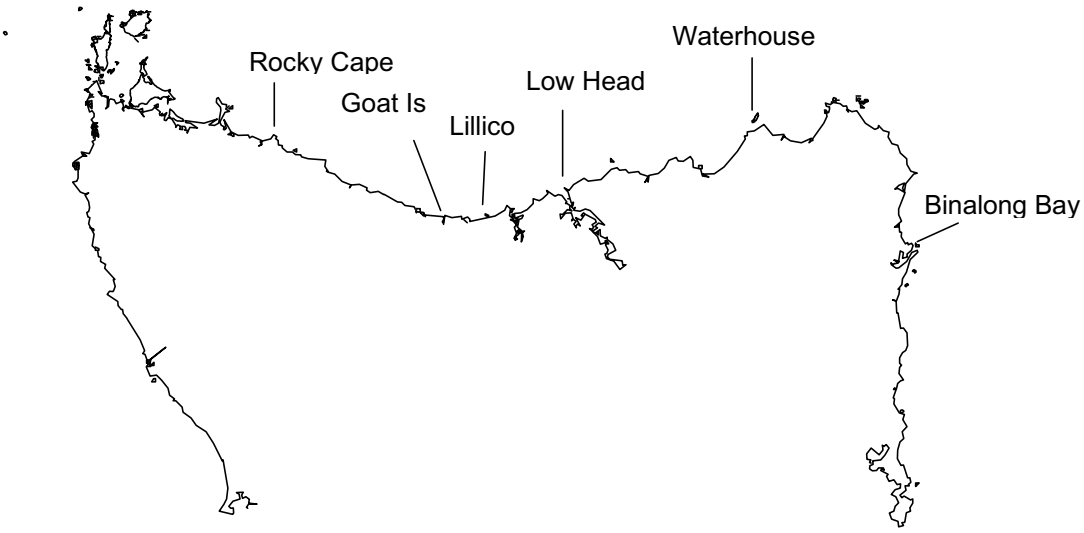

Fig. 2. Location of potential reserve locations examined.

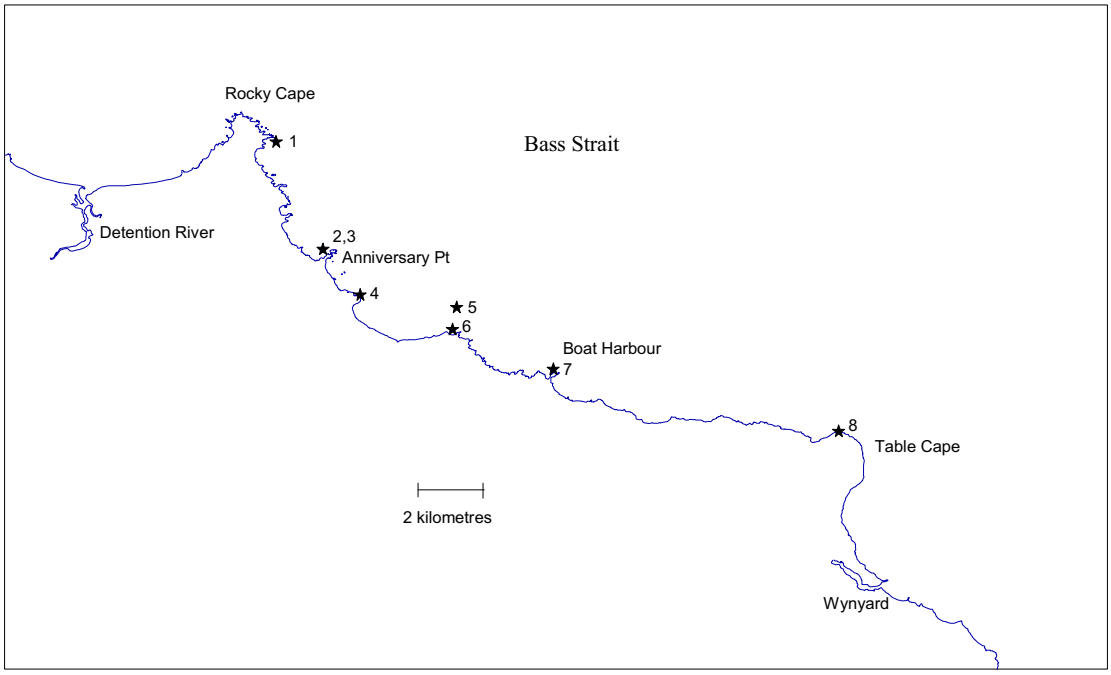

Fig. 3. Section of coastline between Rocky Cape and Table Cape showing sites quantitatively surveyed. Sites are 1 Rocky Cape (5m), 2 Anniversary Pt (5m), 3 Anniversary Pt (10m), 4 West Sisters Beach (10m), 5 Sisters Is (10m), 6 Sisters Rocks (5m), 7 Boat Harbour (5m), and 8 Table Cape (5m).

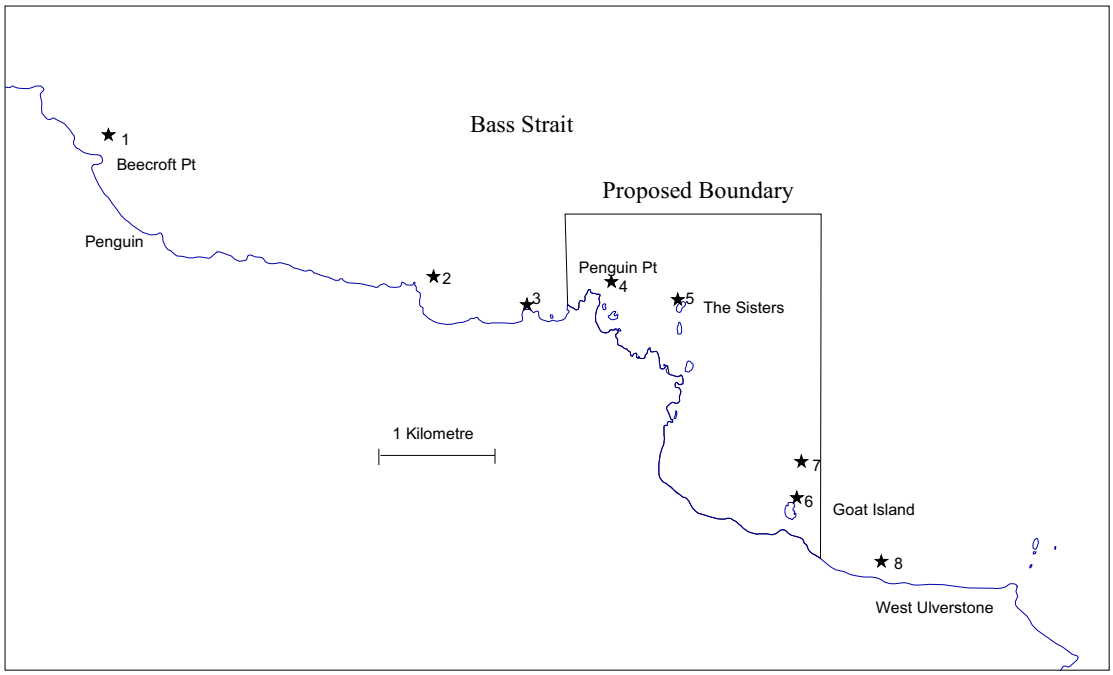

Fig. 4. Coastline in the vicinity of the proposed Three Sisters/Goat Island marine protected area, showing the proposed boundary. Quantitative survey sites are 1 West Penguin (5m), 2 The Piggery (5m), 3 Tee-tree Pt (10m), 4 Penguin Pt (10m), 5 Outer Sister (5m), 6 Goat Is (5m), 7 Goat Is (10m), and 8 West Ulverstone (5m).

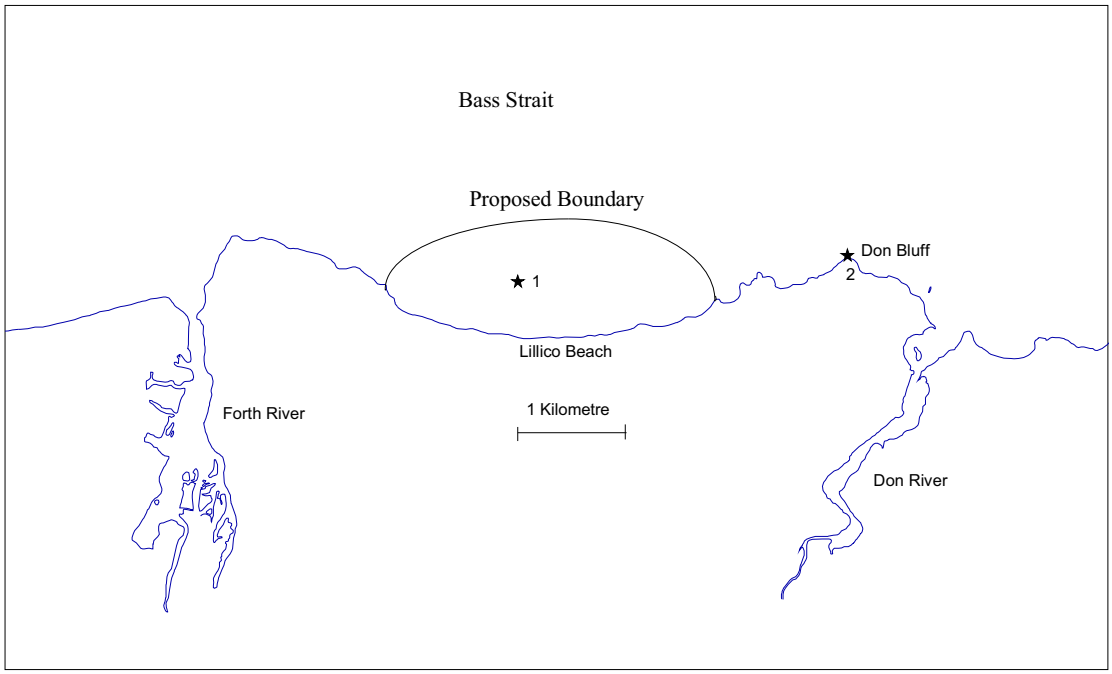

Fig. 5. Coastline in the vicinity of the proposed Lillico Beach marine protected area, showing the proposed boundary. The quantitative survey sites are 1 Lillico Beach (10m), and 2 Don Heads (5m).

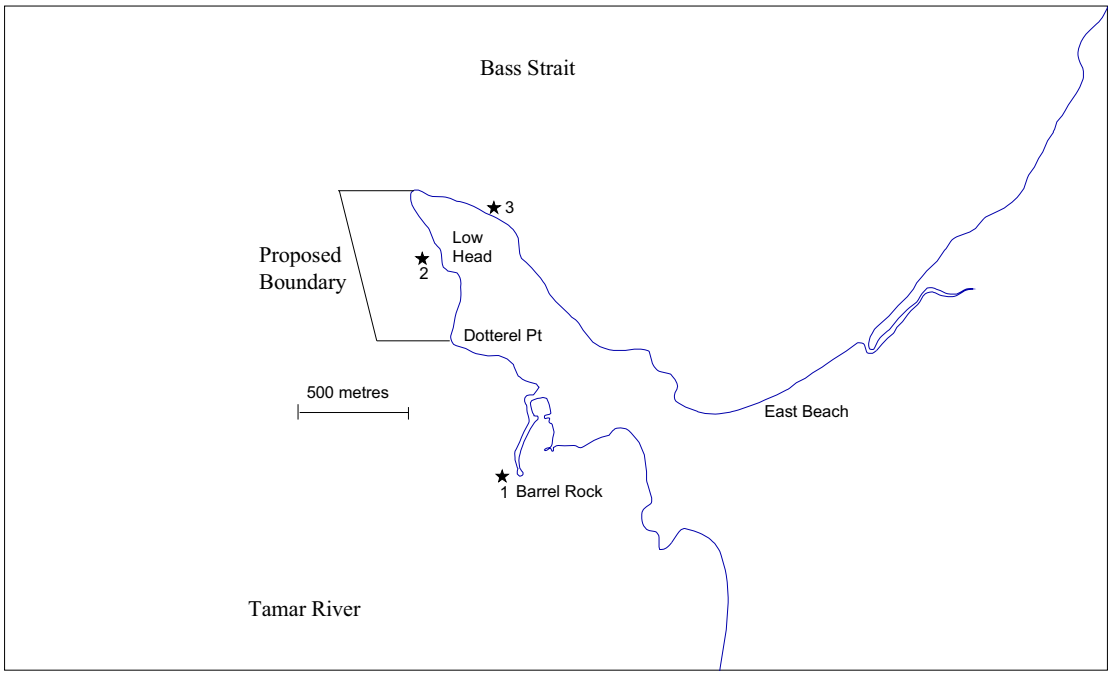

Fig. 6. The coastline in the vicinity of the proposed Low Head marine protected area, showing the proposed boundary. The quantitative survey sites are 1 Barrel Rock (5m), 2 Low Head west (5m), and 3 Low Head east (5m).

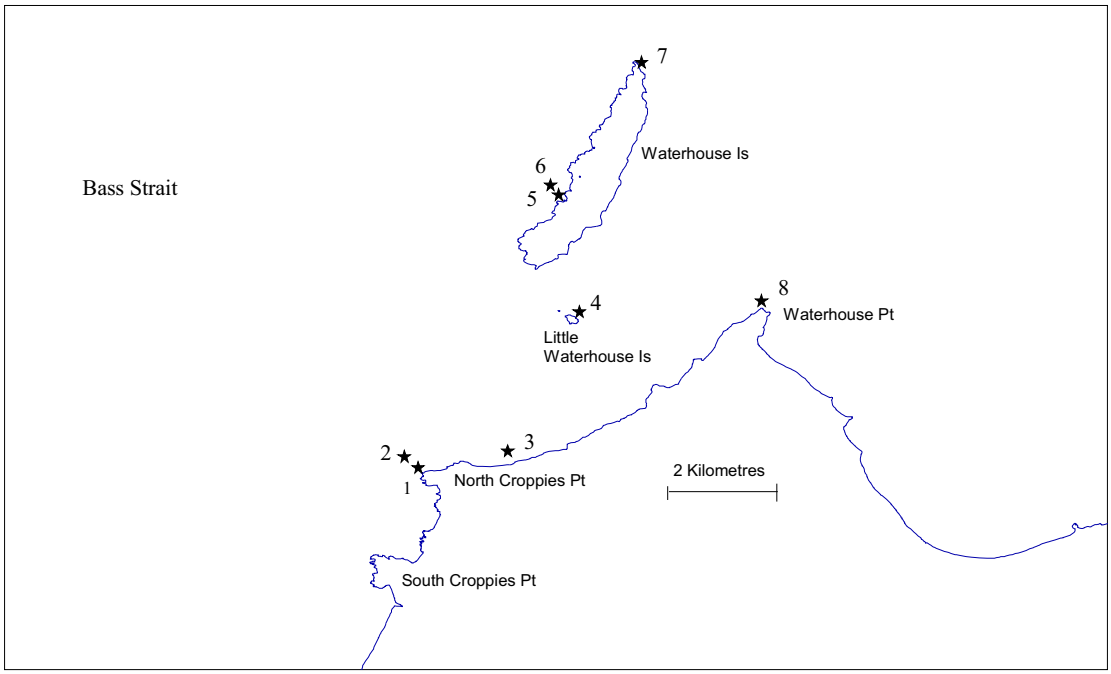

Fig. 7. Coastline of the Waterhouse region on the Tasmanian northeast coast. Quantitative survey sites are; 1 North Croppies Pt (5m), 2 North Croppies Pt (10m), 3 Waterhouse Bay (10m), 4 Little Waterhouse Is (5m), 5 Waterhouse Is west (5m), 6 Waterhouse Is west (10m), 7 Waterhouse Is light (5m), and 8 Waterhouse Pt (5m).

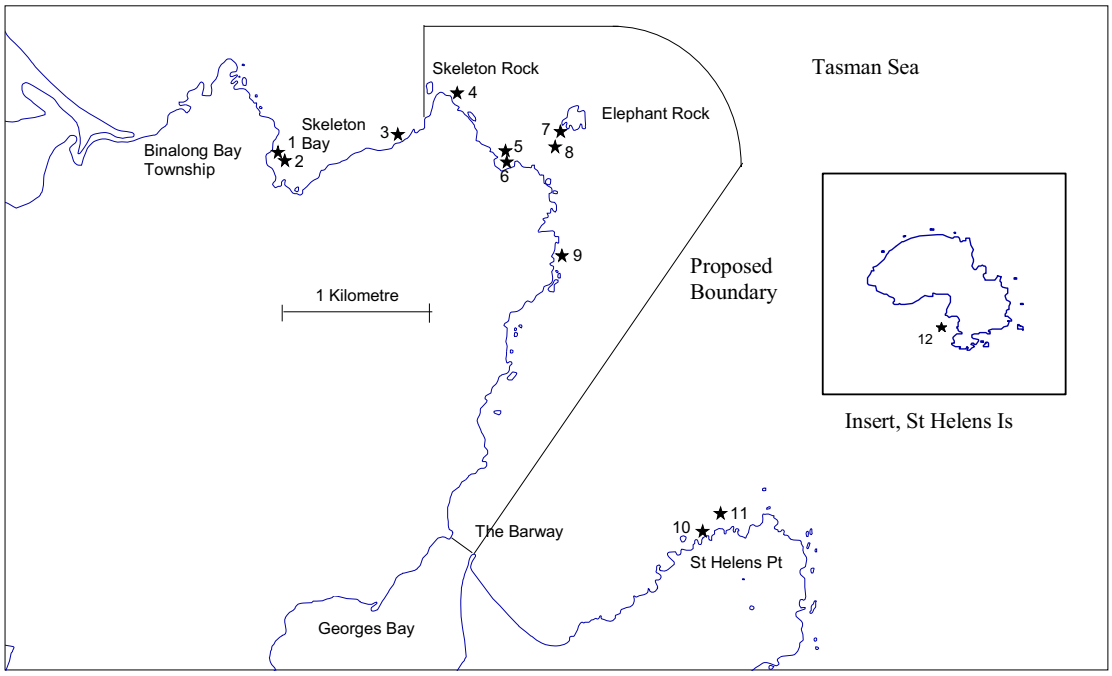

Fig. 8. Coastline in the vicinity of the proposed Binalong Bay marine protected area, showing the proposed boundary. Quantitative survey sites are 1 Skeleton Bay west (5m), 2 Skeleton Bay west (10m), 3 Skeleton Bay east (5m), 4 Skeleton Rock (10m), 5 Grants Pt west (5m), 6 Grants Pt west (10m), 7 Elephant Rock (5m), 8 Elephant Rock (10m), 9 Grants Pt south (5m), 10 St Helens Pt (5m), 11 St Helens Pt (10m), and 12 St Helens Is south (5m).

One of the driving forces behind the establishment of MPA's has been the Federal Government, which through an initial program called Ocean Rescue 2000, and its replacement, the Marine Protected Area program, has encouraged and facilitated the establishment of a comprehensive, adequate and representative network of MPA's around the Australian coastline. In this sense, a marine protected area is "an area of sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means". A major aim of this process is to conserve within protected areas, representative and adequate examples of each distinct habitat type and ecosystem found along the coast, and that each reserve be sufficiently large to adequately protect the species within it (ANZEEC, 1998, 1999). To ensure that distinctly different sections of the coastline are recognised, Environment Australia, with relevant State and Territory governments, conducted a bioregionalisation of Australian coastal waters (IMCRA, version 3.3). This process resulted in the identification of 8 distinct bioregions in Tasmanian coastal waters (Fig. 1) (IMCRA 1998, Edgar *et al.*1994, Edgar *et al.* 1995) based primarily on analysis of a comprehensive dataset of the ranges of reef flora and fauna. These bioregions are essentially structured by distinct differences in ocean currents, ocean temperature, wave exposure and coastal topography, which in turn act to structure the biological community present.

Currently only one of these regions, the Freycinet bioregion, has a protected area of sufficient size to provide some regional conservation benefits (Edgar *et al.* 1995). This is located on the north-eastern coast of Maria Island. At present two additional reserve proposals are well developed; these are at Port Davey in the Davey bioregion, and at the Kent Group of islands in the Gippsland bioregion. If proclaimed, these would add to a total of three Tasmanian bioregions with some degree of representation of species and habitats within a reserve system. Of the remaining regions, the Boags region, consisting of the entire northern coastline, and the Bruny region in the south-east are potentially the high priority regions for establishing reserves, given that these regions have the highest levels coastal development and use, and would probably gain the greatest initial benefit from protection.

To facilitate this process, this study has focussed on examining specific locations in the Boags bioregion, including the TFIC/TASFA proposals, for their potential to act as representative marine protected areas, on the understanding that in the following year surveys will focus on identifying potential locations in the Bruny region and then remaining regions. Surveying the Boags region was in part simplified by the extent of existing information on north coast habitats, and that produced during concurrent surveys of the proposed fish propagation areas.

In an initial survey of potential reserve locations in Tasmania commissioned by the National Parks and Wildlife Service, Edgar (1981) recommended the establishment of a multiple-use reserve extending from Rocky Cape to Boat Harbour, based on observations of high species diversity of algae, fish and invertebrates, predominantly relating to the high structural complexity of reef in the area, coupled with the range of exposures and reef depths available. The natural values of this area have already been recognised by the local diving community, sections of which have been lobbying for a reserve in this area since 1976.

A subsequent review of potential reserve locations in the Bass Strait region conducted a decade later by the Department of Sea Fisheries and the Parks and Wildlife Service (Barrett and Edgar 1992) confirmed the section of coastline between Rocky Cape and Boat Harbour as an ideal location for a representative reserve, and also flagged the suitability of Waterhouse Island and Waterhouse Point as an additional reserve location for the eastern Bass Strait region. Further surveys of north coast marine communities conducted by the Department of Primary Industry and Fisheries and the Parks and Wildlife Service as part of the bioregionalisation process (Edgar *et al.* 1995), in addition to seagrass and habitat mapping (Rees 1993, Edyvane et al. 1999) have failed to reveal alternative suitable locations for open coastal representative reserves in this region, at least for those containing a range of reef habitats in addition to seagrass.

In this study, the two major areas with regional reserve potential (Rocky Cape and Waterhouse) in addition to the TFIC/TASFA proposals, have been mapped in detail, and additional information on the biological communities present within these areas has been collected. This has been conducted with the aim of providing sufficient information on the distribution of habitats and species for choices of appropriate boundaries/zones to be made during the development and stakeholder consultation phases of any specific proposals advanced for representative reserves in this region.

2. Methods

2.1 Mapping

The provision of detailed habitat maps was considered a core component of the reserve assessment process as very little information is available on the distribution of marine habitats in Tasmanian waters, including in areas nominated for protection. In the past this has led to the choice of inappropriate reserve boundaries that have impacted on the effectiveness of the reserves. In addition to habitat information, bathymetric data is sparse and usually at a course scale which is insufficient for reserve planning, and is therefore an important component for mapping.

The mapping techniques used here were developed to allow for maximum integration of existing data, for the efficient collection of additional data, and for the ease of dissemination of outputs. Existing information on coastal outlines, and where possible the intertidal zone, was obtained from the Tasmanian Land Information Bureau (LIB). The LIB collection of aerial photographs was searched to obtain the best image of sub-surface features that was available for each location. The usefulness of these photographs varied substantially between locations depending on conditions on the day that the photographs were taken. On average, photo runs taken on calm days with low swell, high water clarity, high sun angle and no cloud cover could reveal sub-surface details to depths of approximately 12 m, and photographs of this quality were found for most regions.

These photographs were scanned to produce digital images that were imported into the GIS package Mapinfo and rectified to produce the best fit to the 1:25000 coastal outline supplied by LIB. Outlines of major habitat classifications (sand, seagrass, reef) were then hand digitised from these images (heads-up digitising) giving an accurate indication of habitat boundaries to depths of approximately 12 m, at least in areas free from a reef/seagrass mix. In addition to habitat types, small offshore rocks and islands, often not included on the 1:25000 coastline were also digitised from the photos. For areas where patchy reef and seagrass intermixed this method could not discriminate the differences. In addition, where seagrass or reef extended into depths greater than 12 m the outer boundaries could not be determined.

To obtain information on habitats at depths greater than 10 to 12 m, and to gain a better indication of habitat type and the species present, extensive ground-truthing was conducted at each location. This ground-truthing consisted of a mix of detailed mapping from a survey vessel, in addition to qualitative and quantitative dive surveys. The mapping component involved the use of a survey vessel equipped with a differential GPS, sounder, chart-plotter, towed video camera and computer. By using a computer program developed by Andrew Brown (TAFI), position accurate to within one metre could be logged at regular intervals along with the depth and habitat type.

Habitat types were determined either directly by observation with a viewer, or remotely using the sounder output or the towed video camera. The sounder output was sufficient to discriminate reef, low-flat reef and sand, but could not readily discriminate seagrass from sand, particularly in areas of patchy seagrass. Under these conditions observation by towed video was essential beyond visible depths. The video output could be watched live on a monitor on the boat giving real time inputs to the data collected. The major habitat classifications used were mud, sand, seagrass, flat reef, complex reef, and cobble. The latter habitat is common on the Tasmanian north coast. In addition to these classifications, the dominant species present were also recorded, when either viewed directly or via a video drop. The species recorded include species of seagrass and dominant macroalgae. At each location surveyed a grid pattern survey was conducted to intercept as many offshore/onshore and longshore boundary transitions as possible. Where time was limited due to weather, surveys were restricted to an onshore/offshore pattern to maximise the depth information gained for later contouring, and also because in most areas the major habitat changes were usually oriented longshore.

The data collected was transferred to an Excel file where depths were corrected for tidal variation throughout the sampling period. This variation could be up to 2.5 m on the Tasmanian north coast. In addition the data was checked for spurious position errors that are occasionally produced by the GPS and can substantially interfere with depth contouring if undetected. The corrected data was then imported into the GIS package Mapinfo where position and habitat types and species cover could be plotted spatially. By using this information in conjunction with that derived from aerial photographs, detailed habitat distribution maps were able to be produced for each location surveyed. As bathymetric information was sparse for all regions surveyed (with the exception of the Low Head location which is adjacent to a major shipping channel), bathymetry was derived from depth soundings obtained during the surveys.

The contouring program 3D-Mapps was used to analyse the depth data and to produce a contour layer for use with Mapinfo. The program was used to produce contours for the 2 m, 5 m, 10 m, and all subsequent 5 m depth intervals. Smaller interval contours could have been used but would lead to substantial cluttering of subsequent maps. All contours were smoothed by hand. The zero contour was taken as the 1:25000 coastal outline supplied by LIB, in addition to small offshore rocks and islands added from the aerial photos to give more accurate contouring. For Rocky Cape, Low Head, Waterhouse and Binalong Bay depths were from the high tide mark as this is the position of the 1:25000 outline. For the Lillico Beach and Three Sisters-Goat Island locations a low tide outline was available from LIB and this was used to produce contours referenced to the low tide mark.

2.2 Qualitative biological surveys

At each potential reserve location a number of qualitative dive surveys were undertaken to more accurately determine the dominant species present and how they varied with depth and exposure. Diver based observations allowed easier and more reliable community description than that able to be obtained from the benthic video camera. Dives were usually for a short duration, recording the dominant species of macroalgae, large invertebrates and fishes. They covered the depth range from the immediate sub-tidal to the reef edge where this was possible, giving an indication how community structure changed with depth. Sites were selected to include the range of differing exposures present at each location. The qualitative surveys provide a rapid method of obtaining useful descriptive information on the range of species present, both spatially and with depth, however, to more accurately compare locations, quantitative information is needed. While more time consuming, these surveys provide detailed information on species abundance and size that can be used for comparisons in space and time.

2.3 Quantitative biological surveys

Quantitative surveys of macroalgae, mobile megafaunal invertebrates, and fishes were conducted at each location (locations are shown in Figs 3 to 8), with the number of surveys undertaken related to the overall size of the area in question. Survey sites were chosen to give a good spatial coverage of each location. For some locations, existing quantitative information was available from previous surveys, reducing the need for additional surveys. Quantitative surveys were conducted at 5 m and 10 m depth, with depth taken from the mid-tide level. These depths give a good indication of the average reef habitats in the areas examined. Deeper reefs exist in most locations, however, quantitative surveys were not feasible at these depths due to decompression constraints.

As the proposed locations at Binalong Bay and Three Sisters-Goat Island were of sufficient size to show some recovery following protection from fishing, additional quantitative sites were surveyed in adjacent areas external to the reserve proposals. These sites were chosen to be external control sites by which changes within the reserve could be compared in the years following protection. The sites were chosen to be as similar to the reserve sites as possible. At Binalong Bay, six external sites were chosen to match the six sites surveyed within the reserve. In both the proposed reserve and external sites, three of these were at 5 m and three at 10 m depth. The position of these sites are shown in Fig. 8.

At Goat Island a similar baseline design was established, with four sites within the proposed reserve and four external, again with the sites evenly split between 5 m and 10 m. The position of these sites are shown in Fig. 4. From the results of ongoing monitoring in Tasmania's existing reserves (Edgar and Barrett, in press) this level of replication should have sufficient power to detect any biologically significant changes occurring in the reserves following protection. The survey methodology follows that used in existing monitoring of marine reserve performance in Tasmania (see eg., Edgar and Barrett, 1997).

At each site, three methods were needed to adequately census the abundance and size structure of fishes and benthic invertebrates, and the percentage cover of macroalgae. The technique considered most appropriate for censusing large fishes consisted of laying four replicate 50 m transect lines along the 5 m or 10 m depth contour and recording the number and estimated size of fish observed by a diver while swimming along the centre of a 5 m wide strip on either side of the line. This technique is the most commonly used in general census surveys (eg., Choat and Ayling1987, Cole *et al.,* 1990) and although many other techniques exist (eg., visual fast count method of Kimmel 1985; variable distance method of Thresher and Gunn 1987) they are either too complex to use in a baseline survey or are not sufficiently quantitative. While McCormick and Choat (1987) recommend the use of smaller sampling units to improve efficiency, this was not considered viable as this method often leads to many "0" counts for less abundant species, preventing the use of parametric statistics in data analysis and greatly reducing the power of any later analysis.

Smaller fishes and megafaunal invertebrates (large molluscs, echinoderms, crustacea) were also counted along the transect lines used for the fish survey by counting benthic organisms within a one metre strip. The speed was adjusted to suit the location with all sites comprehensively searched, including caves and crevices. The maximum length of abalone and carapace length of rock lobster were measured underwater using calipers as these species were encountered. The cover of macroalgal species was then determined by placing 0.5 x 0.5 m^2 quadrats at 10m intervals along the transect line, and, using a points method, determining the percentage cover of the various plant species.

2.4 Propagation values

Four of the proposed protected areas were nominated for the purposes of fish propagation. As stated in the introduction it is beyond the scope of this study to examine their propagation potential. However, as the conservation of fish stocks is a precursor to enhancing propagation values, some information can be obtained on the potential of each location for protection of stocks of resident fishes. Habitat boundaries such as reef to sand are effective in preventing off-reef movements of common reef species such as wrasses and southern leatherjackets (Barrett 1995a), barber perch, butterfly perch and magpie perch (Barrett 1995b), bastard trumpeter, lobsters and abalone (Edgar and Barrett 1999). Presumably other resident reef species such as banded morwong (Murphy and Lyle 1999) would also be protected by such barriers.

The choice of effective boundaries can therefore have a large influence on the success of a protected area in retaining the species it is intended to conserve. One of the major aims of this study therefore was the identification of suitable habitat boundaries that could be used as protected area boundaries, or as buffers within the area to restrict loss. Suitable boundary choice can both increase the overall conservation value of an area by protecting fish populations in a near natural stale, but also enhance stocks to levels that might make some contribution to propagation.

3. Results

3.1 Binalong Bay

3.1.1 Habitat mapping

Mapping of the proposed marine propagation area at Binalong Bay revealed the presence of a significant extent of reef, particularly to the north of Skeleton Rock and Elephant Rock (Figs 9 to 11), with this reef essentially being sub-surface extensions of Skeleton Point and Grants Point.

The reef extends to almost 45 m depth in places and is comprised mostly of complex granite boulder-fields, with only a limited extent that could be described as low-flat reef. The reef appears to be entirely granitic in origin, reflecting the granite coastline found in this region. The only other habitat type present at this location was medium to coarse sand, extending from sandy beaches to over 45 m depth in the proposed protected area. No evidence of seagrass beds were found, a not surprising result given the high energy nature of this coastline, although seagrass beds are found nearby in the sheltered waters of Georges Bay.

Most of the coastline adjacent to the proposed area is a steep granite embankment that gradually decreases in slope to eventually form beaches as the mouth of Georges Bay is approached. Approximately the southernmost 800 m of coastline in the proposed propagation area is predominantly sandy beach that extends offshore to a sandy sea floor (Fig. 9).

In the area to the west of Skeleton Rock, outside of the proposed propagation area (Fig. 10) there is also a substantial amount of offshore reef of complex structure, both in Skeleton Bay and off the Binalong Bay township itself. The reef off the township extends approximately 300m offshore to a pinnacle in one metre of water before extending a further 200m offshore to a depth of 32m. Two sand patches extend close inshore in Skeleton Bay with the westernmost extension close to a small isolated beach.

3.1.2 Qualitative biological surveys

Surveys at Elephant Rock, Skeleton Rock, and Skeleton Bay indicated a macroalgal flora typical of a sub-maximal exposed coastline in this region. On the islands and outer coastline, the kelp *Durvillaea potatorum* extends from the intertidal zone to depths of 4 m, with *Phyllospora comosa* extending from 4 m to 12 m and *Ecklonia radiata* from 4 m to 30 m, becoming dominant over *Phyllospora* at 10 m. At greater depths than 30 m the reef was predominantly covered with invertebrates. These were predominantly sponges, ascidians and bryozoans. On the less exposed reefs in Skeleton Bay, *Durvillaea* extended to approximately 1.5 m with *Phyllospora* from 1.5 m to 6 m and *Ecklonia* from 4 m to the reef edge. One notable feature of this area was the presence of large barren areas caused by grazing of the urchin *Centrostephanus rodgersii.*

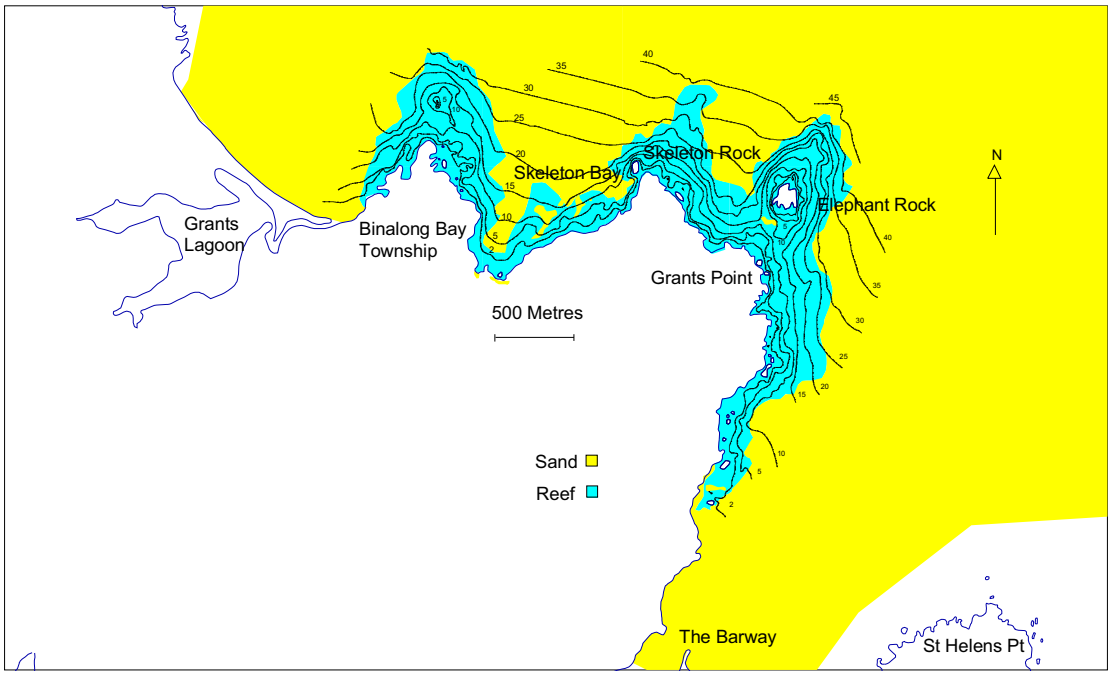

Fig. 9. Coarse scale habitat map of the proposed Binalong Bay Marine Propagation Area and surrounding coastline. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

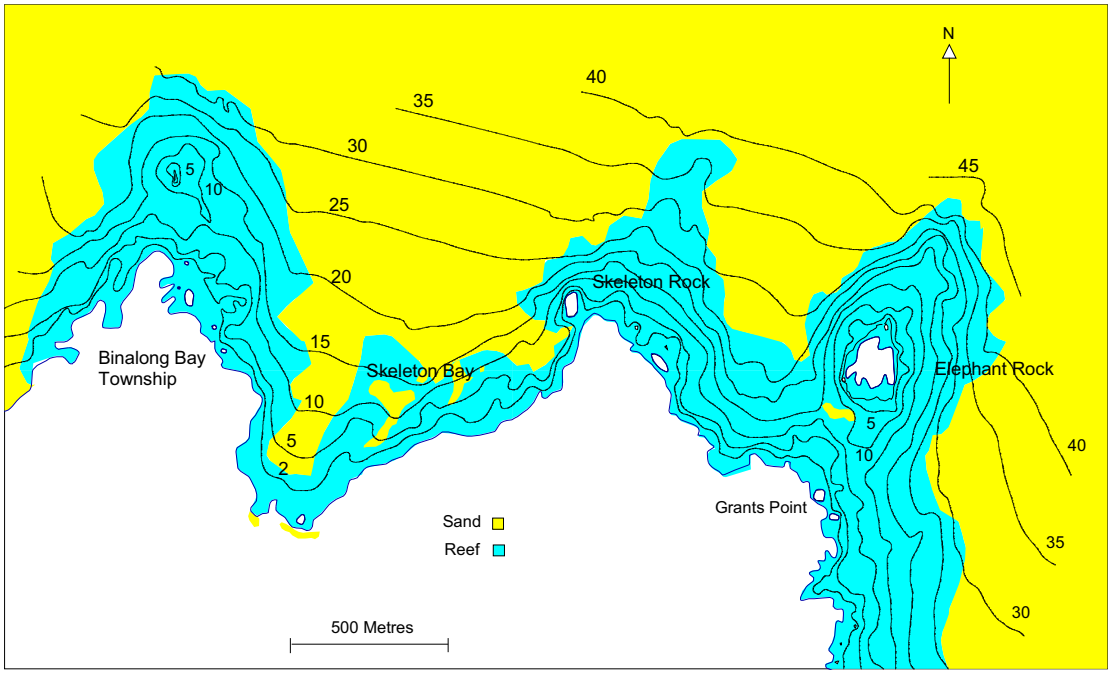

Fig. 10. Detailed habitat map of Binalong Bay coastline from the Binalong Bay township to Elephant Rock. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

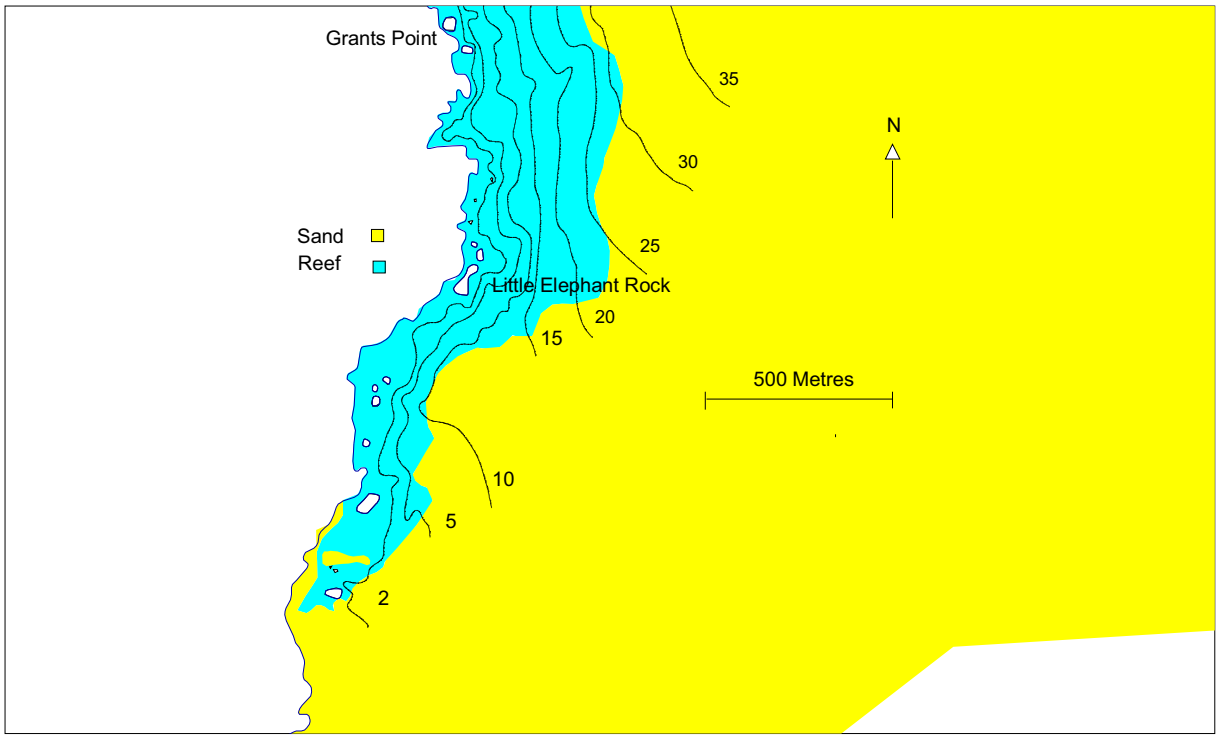

Fig. 11. Detailed habitat map for coastline from Grants Point to the southernmost extent of reef approaching the St Helens Barway. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

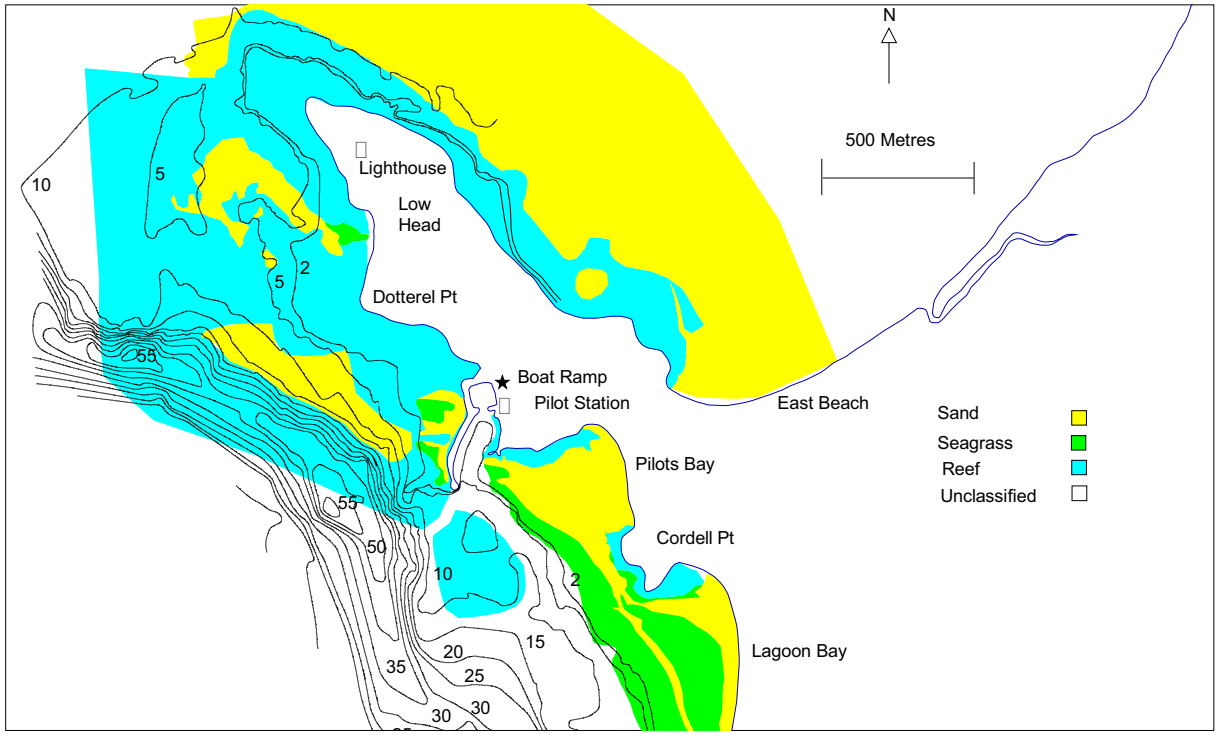

Fig. 12. Broad scale habitat map of Low Head and adjacent coastline. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

These barren zones are characterised by bare rock that has been exposed by the complete removal of the algal canopy. At Elephant Rock, barrens were evident from 10 m to 20 m depth with approximately 30% of the seabed barren at 10m and 70% barren at between 15 m and 20 m. The urchins were not common below 20 m. In Skeleton Bay the barrens were also present, but less pronounced, with small barrens found in 6 m to 10 m. *Centrostephanus* was the most common large invertebrate evident at all sites examined and generally occurred from 5 m to 25 m depth. In urchin barren areas the feather star *Comanthus trichoptera* was often abundant, particularly in Skeleton Bay.

The fish communities were similar at all sites with the most significant differences related to depth. In 0-5 m the most common species were *Notolabrus fucicola* (purple wrasse), *Dactylosargus arctidens* (marblefish), *Penicipelta vittiger* (toothbrush leatherjacket), *Scorpis aequipinnis* (sea sweep) and *Melambaphes zebra* (zebrafish). Between 5-10 m the species were similar but also included *Cheilodactylus spectabilis* (banded morwong), *Notolabrus tetricus* (blue-throated wrasse), *Caesioperca lepidoptera* (butterfly perch), *Trachurus declivis* (jack mackerel) and *Dinolestes lewini* (pike). Other species present but less abundant included *Meuschenia australis* (brown striped leatherjacket), *Parika scaber* (cosmopolitan leatherjacket) , *Eubalichthys gunnii* (velvet leatherjacket), *Odax cyanomelas* (herring cale), *Latridopsis forsteri* (bastard trumpeter), *Pentaceropsis recurvirostris* (long-snouted boarfish), and *Pictilabrus laticlavius* (senator wrasse). *Caesioperca lepidoptera* was particularly abundant at depths below 15 m.

3.1.3 Quantitative biological surveys

Table 1 shows the results of quantitative surveys of macroalgae undertaken in the region in 1993 and 1999. The 1993 results are included to give an indication of how characteristic the proposed area is of the region. *Ecklonia* and *Phyllospora* were the dominant algae at all locations surveyed, with *Phyllospora* most abundant in the 5 m surveys and *Ecklonia* most abundant in the 10m surveys. At most sites there were large numbers of other species present, particularly red algae, but each was only a minor component of the flora at any one site. There was a great degree of similarity between the floral composition of all sites taking depth into consideration, reflecting the limited range of habitats found this region (mostly exposed coast). For the invertebrates (Table 2) the most notable feature was the abundance of *Centrostephanus* at most sites. This species is currently undergoing a range expansion in Tasmanian waters as 20 years ago it was not recorded from this region. It is not only common now but is also substantially altering community structure through the production of large barren zones. The filter feeding feather star *Comanthus trichoptera* appears to prefer these barren zones and is unusually abundant in areas with high *Centrostephanus* numbers. Other common invertebrates in this region include the common urchin *Heliocidaris erythrogramma* which is most abundant in the more sheltered areas, and the blacklip abalone *Haliotis rubra*. The fish community was characterised at most sites by the presence of the reef species *Notolabrus fucicola* (purple wrasse), *Notolabrus tetricus* (blue-throated wrasse), *Penicipelta vittiger* (toothbrush leatherjacket), *Pseudolabrus psittaculus* (rosy wrasse), *Odax cyanomelas* (herring cale) and *Cheilodactylus spectabilis* (banded morwong) (Table 3).

Schooling species such as *Trachinops caudimaculatus* (hulafish), *Dinolestes lewini* (pike), *Caesioperca rasor* (barber perch), *Caesioperca lepidoptera* (butterfly perch) and *Trachurus declivis* (jack mackerel) were occasionally abundant when schools were encountered. Notable features were the presence of *Heterodontus portusjacksoni* (Port Jackson shark), *Kyphosus sydneyanus* (silver drummer), *Melambaphes zebra* (zebrafish), *Atypichthys strigatus* (mado sweep), and *Parma microlepis* (whitear), species rarely found further south in Tasmanian waters.

Table 1. Percentage cover of Macroalgae and encrusting invertebrates on quantitative algal transects in north-eastern Tasmania in 1993 and 1999. Table continues next page.

Site	St Helens Is	St Helens Rocks	Skeleton Bay (west)	Gardens Rocks	Gardens Rocks	Eddystone Pt (south)	Eddystone Pt (south)	Eddystone Pt (north)	St Helens Is (south)	St Helens Pt	St Helens Pt	Grants Pt (south)	Grants Pt (west)	Grants Pt (west)	Elephant Rock	Elephant Rock	Skeleton Bay (east)	Skeleton Rock (east)	Skeleton Bay (west)	Skeleton Bay (west)
Depth (m)	5	5	5	5	10	5	10	5	10	10	5	5	5	10	5	10	5	10	5	10
Year	93	93	93	93	93	93	93	93	93	99	99	99	99	99	99	99	99	99	99	99
Species																				
Invertebrate cover																				
Bryozoans (soft)	0	0.2	3.5	6.6	2.1	0.3	1	0	9.4	2.5	0.2	1.3	1.2	4.2	0	0	6.3	6.9	0	5.5
Sponges	0.3	0.4	0	0	0	0	0.2	0	1.9	0	0	1	0.9	0	0	0	0.8	0	0	0.2
Ascidians	0	7.9	0.4	5.5	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown algae																				
Acrocarpia paniculata	0	0	1.7	0.2	3.6	0	1.6	0	0	0.7	0	0	0	1.9	0	0	2.3	1.9	1.2	2
Carpoglossum confluens	0	0	6.7	0	0.9	0	0	0	0	5.1	0	0	1.1	3.1	0	1.6	2	4.3	1.4	9.3
Carpomitra costata	0	0	1	0.1	0.2	0	1.7	0	1.5	0.4	0.4	0	1	1.9	0	0.2	0.6	1.2	1	0
Cystophora platylobium	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dictyota dichotoma	0	0	0.2	0	0	0	0	0	0	0	0	1.2	0	0	0	0.3	0	0	0	0
Distromium spp.	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Durvillaea potatorum	0	17	0	3.5	0	1.4	0	18	0	0	0	1	0	0	0	0	0	0	0	0
Ecklonia radiata	32	24	55	57	79	15	32	9.8	90	40	25	30	57	64	30	46	64	67	21	58
Halopteris spp.	0	0	6.3	0	6.9	0.1	0.1	0	0	5.8	3.4	0.9	5.5	13	0	1.6	2	1.7	1.9	0
Homeostrichus olsenii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0
Lessonia corrugata	0	17	0	1.5	0	11	0.2	0.5	0	0.3	0	0	0	0	2.3	3.1	0	0	0	0
Lobospira tricuspidata	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0
Phyllospora comosa	70	53	47	48	18	75	66	75	19	48	69	71	57	19	74	16	43	32	72	26
Sargassum spp.	0.2	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Xiphophora gladiata	0	0.5	0.6	0	0.3	0	0	0	0	0.8	0	0	2.5	0	0	0	0	0	0.4	0
Zonaria angustata	0	0	0	0	0	0	0	0	0	0	0.7	1.8	0.4	0	0.4	0	0.4	0	0.3	0.3
Zonaria turneriana	0	0	1.2	0	0	0	0.1	0	0	1.6	0	0	0	3	0	0	0	0	0	0
Green algae																				
Caulerpa annulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0
Caulerpa brownii	0	0	0	0	0.2	0	0.2	0	0	0	0	0	0	0	0	0	0	7	0	0
Caulerpa flexilis	0	0	0	0	2.2	0	0	0	0	0	0	0	0	1.9	0	1.5	0.8	1.4	0	8
Caulerpa trifaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.9	0.3	1	0	0
Codium australicum	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Codium dimorphum	0	0.7	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0
Codium pomoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0
Codium spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0
Ulva spp.	0	0	0.6	0	0	0	0	0	0	1	14	0	0	0	0	0	7.5	0	0.2	0.4

Table 1 (continued). Percentage cover of Macroalgae and encrusting invertebrates on quantitative algal transects in north-eastern Tasmania in 1993 and 1999.

Site	St Helens Is	St Helens Rocks	Skeleton Bay (west)	Gardens Rocks	Gardens Rocks	Eddystone Pt (south)	Eddystone Pt (south)	Eddystone Pt (north)	St Helens Is (south)	St Helens Pt	St Helens Pt	Grants Pt (south)	Grants Pt (west)	Grants Pt (west)	Elephant Rock	Elephant Rock	Skeleton Bay (east)	Skeleton Rock (east)	Skeleton Bay (west)	Skeleton Bay (west)
Depth (m)	5	5	5	5	10	5	10	5	10	10	5	5	5	10	5	10	5	10	5	10
Year	93	93	93	93	93	93	93	93	93	99	99	99	99	99	99	99	99	99	99	99
Species																				
									Red algae											
Ballia callitricha	0	2.4	1.7	3.8	2.9	3.2	1.4	0.9	0.1	1.3	0	0.6	1.3	0.8	0.5	0.6	1.3	1.3	0.4	0.7
Ballia scoparia	0	0	3.5	0	0	0.2	0	0	0	0	0	0	0.2	0	0	0	0.2	0	0.2	0.8
Bangia spp.	0	0	0.7	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Callophyllis lambertii	0	0	0	0	0	0	0	0	0.5	0	0	0	0.5	0	0	0	0	0	0	1.3
Callophyllis rangiferinus	0	0	1.3	0.5	0	0.1	0.5	0	0.6	0.4	0	0	0	0	0.6	0	0.9	0.3	0.2	0
Champia viridis	0	0	0	0	0	0	0	0	0.3	0.8	0	1.2	0	0.2	0	0	0.2	0	1	0
Craspedecarpes ramentosus	0	0	0	0	0	0	0	0	0	1.2	0	0	0.2	0.2	0	0	0	2	0	0.8
Delisea spp.	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Dictymenia harveyana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0
Echinothamnion hystrix	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0
Euptilota articulata	0	0	0.3	0.2	0.5	0	0.3	0.1	0.5	0.6	0.2	0	0.1	0.2	0	0.1	0	0	0	0.4
Gelidium spp.	0	0	2.3	0	0	0	0	0	0	0.1	0	0	0.4	0	0	0	0	0.5	0	0
Gigartina sp.	0	0	0	0	0	0	0	0	0	0	0.3	4.8	2.3	0	0	0	0	0	0	0
Haliptalon roseum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0	0	1.1	0
Hemineura frondosa	0	0	0.4	0	0	0	0.1	0	0	0.2	0.2	0	0.9	0	0	0.1	0	0	0.1	0
Jeannerettia lobata	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3
Laurencia elata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0
Laurencia spp.	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0
Lenormandia marginata	0	0	0.7	0.4	0.2	0	0.2	0	2.7	2	0	1.8	2	0.4	0	1.2	0.6	2.9	1.7	1.1
Melanthalia obtusata	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0
Peyssonelia novaehollandiae	0	0	2.7	2.3	5.6	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0.4	0
Phacellocarpus alatus	0	0	0	0	0	0	0	0	0	0.2	4.7	0	0.3	0	0	0	0	0	0	1.7
Phacellocarpus peperocarpus	0	0	1.5	0.4	3.9	0	3.4	0.4	0.6	3.3	0.4	0.6	1.1	1.9	0	0.1	0	2.5	0.2	3.4
Plocamium angustum	0	0	1.1	0.8	0.4	0	0.6	0.4	0	0.7	0.7	1	0.7	0.9	0	0.1	1.1	0	0	0.6
Plocamium cartilagineum	0	0	0	0	0	0	0	0	1.2	2.3	0	0.1	0.1	0.3	0	0.2	0	0	0.3	0.4
Plocamium costatum	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0.5	0	0
Plocamium dilatatum	0	0.9	0.4	0.5	0.7	1	0.3	0	2.7	0	0	2.8	0.7	0.4	0.8	0.7	0	0.4	0.9	0
Plocamium leptophyllum	0	0	0.7	0.8	0.9	0	0.9	0.9	0	0	0	0	0	0	0	0	0	0	0.1	0
Plocamium mertensii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0
Plocamium potagiatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	0	0	0.1	0
Ptilonia australicum	0	0	0.4	0	1	0	0	0	0	0.2	0	0	0.2	0.5	0	0.5	0	1.6	0	0.8
Rhodomenia spp.	0	0	0	0.4	1	0	1.9	0	3.2	0.9	0	0.5	1.5	1.1	3.9	1.2	1.3	2.4	0	0.7
Sonderopelta coriacea	0	0	0	0	2.4	0	0.4	0	5.2	1.3	0	0.7	0	4.5	0	0.2	1.8	2.3	0.3	5.1
Thamnoclonium dichotomum	0	0	0	0	0	0	0.4	0	0.9	1.2	0	0	0	0	0	0	0	0	0	0
Unidentified thallous reds	0	1.8	2.6	3.4	3	3.2	3.2	3.3	0.1	0.8	0	1	0.5	0.7	0	1.9	0.2	0	2.9	0.2
Filamentous red algae	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0.4	0	0	0
Genniculate corralines	0.2	1.2	0.9	7.9	11	2.3	9.8	0.1	2.6	1.6	0	0.8	7.9	1.8	0	0	0.1	4.6	0	1.8
									Seagrass											
Halophila australis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.7

Table 2. Abundance of invertebrates and cryptic fishes recorded per site on quantitative invertebrate transects conducted in north-eastern Tasmania in 1993 and 1999.

Site	St Helens Is	St Helens Rocks	Skeleton Bay (west)	Gardens Rocks	Gardens Rocks	Eddystone Pt (south)	Eddystone Pt (south)	Eddystone Pt (north)	St Helens Is (south)	St Helens Pt	St Helens Pt	Grants Pt (south)	Grants Pt (west)	Grants Pt (west)	Elephant Rock	Elephant Rock	Skeleton Bay (east)	Skeleton Rock (east)	Skeleton Bay (west)	Skeleton Bay (west)
Year	93	93	93	93	93	93	93	93	99	99	99	99	99	99	99	99	99	99	99	99
Depth	5	5	5	5	10	5	10	5	10	10	5	5	5	10	5	10	5	10	5	10
Species																				
Cryptic fishes																				
Scorpaena papilosa	0	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Norfolkia clarkei	1	0	2	0	1	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
Heteroclinus tristis	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heteroclinus johnstoni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Crustaceans																				
Jasus edwardsii	1	0	1	0	0	0	4	0	4	4	3	1	3	2	0	2	4	1	2	4
Nectocarcinus tuberculatus	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	1
Pagurid (grey)	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Plagusia chabrus	20	7	7	5	1	3	9	9	3	1	12	21	10	2	7	6	6	6	5	8
Trizopagurus strigimanus	4	1	1	0	0	0	1	0	7	1	4	1	2	1	5	0	3	5	7	2
Echinoderms																				
Astrodiscides truncatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Austrofromia polypora	0	2	0	3	0	0	1	0	0	1	0	0	0	0	0	2	0	1	0	0
Centrostephanus rodgersii	1	2	19	3	23	0	0	0	164	6	0	27	33	83	174	387	318	123	63	120
Comanthus tasmaniae	1	0	0	0	0	0	23	0	5	0	4	4	1	0	0	3	4	2	0	0
Comanthus trichoptera	68	49	317	27	116	14	19	4	256	252	6	467	128	362	248	520	821	147	76	355
Coscinasterias muricata	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Goniocidaris tubaria	0	0	1	2	0	0	3	0	4	8	0	1	0	1	0	1	1	0	1	2
Heliocidaris erythrogramma	1	0	58	1	6	0	0	0	61	32	2	56	23	122	29	24	282	81	31	102
Holopneustes inflatus	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0
Nectria ocellata	0	4	0	1	1	0	0	0	9	4	0	0	2	6	0	4	1	5	0	5
Petricia vernicina	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2
Stichopus mollis	1	0	0	0	0	0	0	0	9	3	0	0	0	1	0	3	1	1	0	0
Molluscs																				
Argobuccinium vexillum	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	1	0	0
Cabestana tabulata	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	2	2	0	0	0
Charonia rubicunda	0	0	1	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	1	0
Haliotis rubra	48	14	43	11	7	14	9	34	27	70	79	48	49	51	172	35	45	8	26	70
Octopus sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleuroploca australasia	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ranella australasia	0	1	1	0	0	0	0	0	1	0	2	0	0	1	0	0	0	1	2	0
Thais orbita	1	3	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Turbo undulatus	0	0	0	3	0	14	3	2	0	1	0	0	4	0	9	0	0	0	1	0

Table 3. Abundance of fish and cephalopods recorded per site on quantitative fish transects conducted in north-eastern Tasmania in 1993 and 1999.

Site	St Helens Is	St Helens Rocks	Skeleton Bay (west)	Gardens Rocks	Gardens Rocks	Eddystone Pt (south)	Eddystone Pt (south)	Eddystone Pt (north)	St Helens Is (south)	St Helens Pt	St Helens Pt	Grants Pt (south)	Grants Pt (west)	Grants Pt (west)	Elephant Rock	Elephant Rock	Skeleton Bay (east)	Skeleton Rock (east)	Skeleton Bay (west)	Skeleton Bay (west)
Year	93	93	93	93	93	93	93	93	99	99	99	99	99	99	99	99	99	99	99	99
Depth (m)	5	5	5	5	10	5	10	5	10	10	5	5	5	10	5	10	5	10	5	10
Species																				
Aplodactylus arctidens	2	7	3	1	0	3	0	1	0	0	1	0	0	0	2	0	0	1	0	0
Apogon conspersus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Aracana ornata	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atypichthys strigatus	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Bovichtus angustifrons	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0
Caesioperca lepidoptera	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	33	0	0	0	1
Caesioperca rasor	0	0	0	0	0	0	0	0	1	0	0	0	0	68	1	29	0	3	0	30
Caranx dentex	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cephaloscyllium laticeps	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cheilodactylus spectabilis	0	6	2	6	8	11	16	3	2	3	2	0	2	1	4	13	1	9	6	1
Dinolestes lewini	2	0	1	4	0	1	27	3	0	0	4	16	4	3	9	0	0	0	7	0
Diodon nichthemerus	0	2	0	0	0	0	0	1	1	1	0	0	0	0	0	2	0	1	0	0
Dotalabrus aurantiacus	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Eubalichthys gunnii	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
Heteroclinus johnstoni	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Heterodontus portusjacksoni	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kyphosus sydneyanus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Latridopsis forsteri	0	0	0	0	0	0	0	0	2	0	6	0	0	0	0	0	0	0	0	0
Lotella rhacinus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melambaphes zebra	24	0	0	0	0	0	1	2	0	0	2	0	0	0	0	1	1	0	1	0
Meuschenia australis	7	2	1	0	0	0	2	1	3	2	1	0	0	4	0	0	9	0	1	2
Meuschenia freycineti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Norfolkia clarkei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Notalabrus fucicola	22	17	7	2	1	71	23	6	11	7	28	2	7	2	20	4	10	6	7	17
Notalabrus tetricus	0	0	1	0	5	3	7	0	7	4	6	2	2	5	2	4	3	4	1	2
Odax cyanomelas	2	5	6	11	7	7	1	3	2	1	0	2	1	3	5	5	2	9	0	0
Parika scaber	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Parma microlepis	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Pempheris multiradiatus	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	1	0
Penicipelta vittiger	29	4	5	5	1	0	1	6	21	1	15	7	2	5	3	4	2	2	2	4
Pentaceropsis recurvirostris	0	1	1	1	0	0	1	0	0	2	0	0	0	1	1	1	0	0	0	0
Pictilabrus laticlavius	1	0	2	0	2	0	0	0	0	3	0	1	1	4	0	0	0	4	0	4
Pseudolabrus psittaculus	0	0	0	0	6	0	0	0	3	3	0	0	0	13	2	14	2	19	0	9
Scorpis aequipinnis	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	18	0	0	1	6
Scorpis lineolatus	0	4	5	10	0	30	0	0	0	0	0	0	0	0	1	0	0	2	0	0
Siphonognathus beddomei	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Squid sp.	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0
Torquigener glaber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Trachinops caudimaculatus	0	0	85	50	20	0	0	0	2	0	0	0	43	141	4	55	1	88	0	20
Trachurus declivis	222	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Urolophus cruciatus	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

3.1.4 Discussion

The proposed marine protected area would protect a typical section of exposed coastline and associated habitats in the Tasmanian north-east. As this proposal contains a substantial amount of complex reef with abundant crevice structure, and is currently subject to a high level of fishing, it is likely to support an expanded fish population including rock lobster and abalone if protected. The benefits of a protected area at this location include the protection of communities on shallow to deep (42 m) reef and sand habitats subject to sub-maximal exposure, in an area with relatively easy public access via a boat-ramp at Binalong Bay. To maximise the conservation and fish stock enhancement benefits of the current proposal however, boundary changes are recommended to protect stocks within the area from the impacts of fishing at its boundary. These changes would essentially require an extension of the proposed boundary offshore from Skeleton Rock and Elephant Rock to ensure the complete offshore extension of the reef is included within the reef, protecting the deep reef habitat and providing for a buffer zone around it. In addition, the proposed western boundary should run northwest rather than north. This would allow the inclusion of a sand patch within the reserve that would act as a natural boundary helping to minimise loss from the reserve. A more substantial sand barrier exists on the western shore of Skeleton Bay. The extension of the proposed boundary to the western shore of Skeleton Bay to include this sand patch is recommended to more effectively buffer fish stocks within the reserve, and to include the more sheltered habitats found in the central section of Skeleton Bay. This would broaden the conservation benefits of this proposal and including a more sheltered location for public access from the shoreline.

3.2 Low Head

3.2.1 Habitat Mapping

Mapping at Low Head identified three major habitat types (Figs 12 & 13). These were reef, seagrass and sand. The reef was generally moderate to low relief, although small sections of higher relief are scattered throughout the area. Generally the relief decreased with depth, particularly in the scour zone associated with the main river channel. There appears to be substantial development of reef to the west of Low Head with reef extending at least 500 m beyond the proposed boundary out to Middle Bank and possibly to the main river channel. The outer section beyond Middle Bank was not examined due to difficulty operating the benthic video in the strong tidal currents found there. However, sounder profiles in this channel area and diver observations at Barrel Rock suggest the main channel is reef, at least at depths beyond 20 m where the channel walls are steep and scoured by strong currents. At low tide, the extent of reef on Middle Bank can often be seen by the extensive beds of string kelp *(Macrocystis angustifolia*) whose floating fronds break the surface in late spring. This plant appears to colonise reef to 7 m depth in this location, often forming dense beds that seem to thrive in the high current and nutrient rich waters associated with the river channel. Several large sand patches were identified to the west of Low Head, one of which extends through a seagrass bed to a small beach in the vicinity of the penguin viewing platform. Only one seagrass bed exists in the proposed protected area, although there is a much more extensive development of seagrass along Pilots Bay and Lagoon Bay to the south of Low Head.

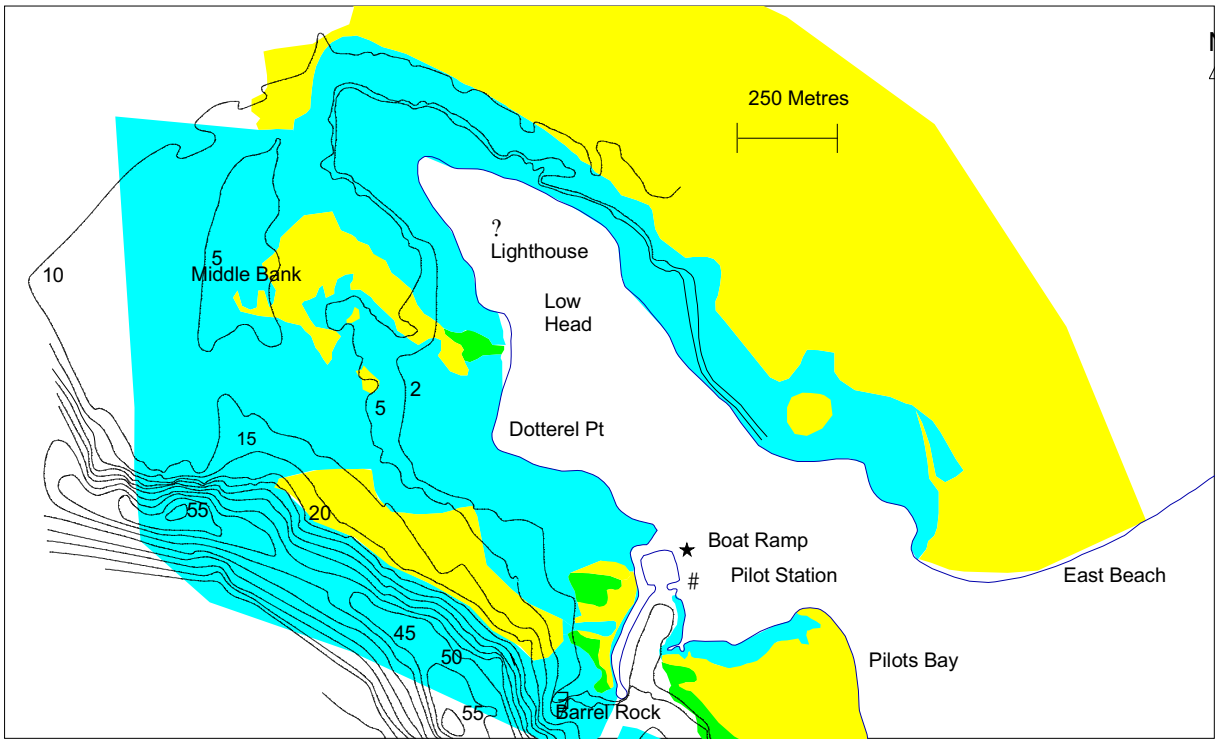

Fig. 13. Detailed habitat map of coastline associated with the proposed Low Head Marine Propagation Area and surrounding waters. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

The large seagrass bed at Low Head and adjacent to Barrel Rock was composed entirely of *Amphibolis antarctica,* a species also found growing more sparsely on reefs throughout this area. The beds in Pilots Bay and Lagoon Bay were dominated by *Posidonia australis,* a species covering large areas of the seabed between 0.5m and 5m depth. A sparse covering of *Heterozostera tasmanica* was found fringing the *Posidonia* beds, with occasional fronds amongst the *Posidonia.* Some *Amphibolis antarctica* was also present, but as isolated patches within the larger *Posidonia* beds.

3.2.2 Qualitative surveys

Within the proposed propagation area, the reef habitat varies little, not surprising given the small section of coastline present (approximately 700 m). This reef is moderately exposed, typical of the northern Tasmania coastline. The macroalgal flora is characterised by *Hormosira banksii* and *Xiphophora chondrophylla* in the intertidal fringe, with *Acrocarpia paniculata, Macrocystis angustifolia* and *Cystophora moniliformis* extending from the lower intertidal to 3 m. Below 3 m is a mixed flora, with *Ecklonia radiata, Acrocarpia, Carpoglossum confluens Cystophora moniliformis, Sargassum sonderi, Sargassum fallax* and *Cystophora retroflexa.* At the sand edge at approximately 7 m, *Scabaria agardii* and *Amphibolis* were common. The invertebrates *Haliotis rubra* (blacklip abalone) and *Heliocidaris erythrogramma* (common urchin) were common at depths below 2 m, with the greenlip abalone *Haliotis laevigata* common on the deeper reef sections and around the sand margins. Fish were present in low numbers, presumably due to the absence of crevice structure on the reef in this area, in conjunction with high currents that are also characteristic of the area. The most common species sighted were *Notolabrus fucicola* (purple wrasse), *Notolabrus tetricus* (blue-throated wrasse), with occasional *Dactylosargus arctidens* (marblefish) and *Diodon nichthemerus* (globefish).

3.2.3 Quantitative surveys

Only one quantitative survey was conducted in the proposed propagation area given its small size, however, survey details are available from two adjacent sites (Barrel Rock and Low Head east, Fig. 6) that have been surveyed regularly following the Iron Barren oil spill (Edgar and Barrett, 1999) and are included with the summary tables for comparison. The macroalgal community at this site was not dominated by any particular species, with *Acrocarpia paniculata, Caulocystis uvifera, Cystophora moniliformis, Cystophora retroflexa, Sargassum sonderi, Sargassum fallax* and geniculate coralline algae major components of the flora in addition to a number of minor species (Table 4). The macro-invertebrates were dominated by *Heliocidaris erythrogramma* (common urchin) and *Haliotis rubra* (blacklip abalone) that were both particularly abundant at this site, presumably because they feed on drift algae transported by the strong tidal currents found there. Other species present in moderate abundance were *Haliotis laevigata* (greenlip abalone), *Patiriella brevispina* (seastar) and *Comanthus trichoptera* (featherstar) (Table 5). As noted during the qualitative survey, the fish fauna was particularly depauperate at this site, with only 7 species recorded on the quantitative transect (Table 6), a value significantly below the average for the other north coast sites examined (Tables 6 & 9).

Table 4. Percentage cover of Macroalgae and encrusting invertebrates on quantitative algal transects in northern Tasmania in 1993 and 1999. Table continues next page.

Site	West Penguin	The Piggery (Penguin)	Tee-Tree Pt	Penguin Pt	Outer Sister Is	Goat Is	Goat Is	West Ulverstone	Lilico Beach	Don Heads	Horseshoe reef (Wesley Vale)	Barrel Rock (Low Head)	Low Head (west shore)	Low Head (East shore)
Year	99	99	99	99	99	99	99	99	99	93	93	95	99	93
Depth (m)	5	5	10	10	5	5	10	10	10	5	5	5	5	5
Species														
						Invertebrate cover								
Bryozoans (soft)	0	0	1.4	0	0.4	0	0	0	0	0	0	0	0	0
Bryozoans (hard)	0.1	0	0	2.3	0	0.1	2.1	1.6	0.4	0	0	0	0	0
Sponges	0	0	1.2	4.3	0	0	3.9	1.2	2.9	0	0	0	0	0
Alcyonarians	0	0	0.3	0	0	0	0	4.4	0.9	0	0	0	0	0
						Brown Algae								
Acrocarpia paniculata	4	12.2	0	0	11	6.6	0	0	3.8	29	36	2	15	42
Asperococcus bullosus	0	0	0.8	0	0.9	0	0.5	0	0.2	0	0.3	0	0	0
Bellotia eriophorum	0	0	0	0	0	0	0	0	1.2	0	0	0	0	0
Carpoglossum confluens	0	0	3.3	0	3.2	0	0	0.9	0	0	0	4.2	1.1	2.4
Caulocustis uvifera	0	0	0	0	0	0	0	0	0	0	0	0	6.3	11
Caulocystis cephalornithos	0	0	0	0	0	1.6	0	0	0	0	0	0.3	0	0
Cladostephus spongiosus	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0
Cystophora monilifera	0	0	0	0	0	0	0	0	0	0	0	0	2.7	0
Cystophora moniliformis	0.9	0	0	0	0	1.6	0	0	0	0.6	0	7.1	8.4	0.6
Cystophora polycistidea	0	0	0	0	0	0	0	0	0	0	0	0	0	16
Cystophora retroflexa	0	0	0	0	0	1	0	0	0	4.5	0.2	13	12	11
Cystophora xiphocarpa	0	0	0	0	1.4	0.2	0	0	0	0	0	0	0	0
Dictyopteris muelleri	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
Dictyota sp.	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0
Dictyota dichotoma	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0
Ecklonia radiata	0.4	0	0	0	10.8	1.4	0.3	0	0	25	7.4	46	1	0.5
Halopteris spp.	4	1.3	0	0	5.7	6.8	1.1	0	0.4	8.1	1	3.8	0.6	2.5
Lobophora variegata	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0
Macrocystis angustifolia	0	0	0	0	0.8	0	0	0	0	0	0	5.3	2.8	0.2
Padina fraseri	0	0	0	0	0	0	0	0.4	0.2	0	0	0	0	0
Perithalia cordata	0	0	0	0	1.4	0	0	0	0	1.8	0.2	0	0	0
Phyllospora comosa	0	0	0	0	0	0	0	0	0	0	0	4.1	0	0
Sargassum decipiens	0	0	0	0	0	0	0	0	0.4	0	0	0.6	0	0
Sargassum fallax	2.3	0	0.3	0	0.9	0	0	0	0	0	0	0	4.1	0
Sargassum heteromorphum	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0
Sargassum sonderi	0	3.6	0	0	4.9	0.3	0	0	0	6	1.3	1.1	11	5.6
Sargassum spp.	2.4	0.7	0	0	0	1.5	0	0	0	0	0.2	17	0	0
Sargassum varians	0.5	0.4	0	0	0.6	0.7	0	0	0	0	5.7	0	0	2.2
Sargassum vestitum	0	0	0	0	0	0	0	0	0	0.3	0.6	0	0	1.3
Scaberia agardhii	0	0	0	0	0	0.1	0	0	0	2.1	0	0	0	0
Seirococcus axillaris	0	0	0	0	0	0	0	0	0	1.5	1.8	6.2	0	0
Sporochnus spp.	0	0.7	0	0	0	0	0	0	0	0	0	0	0.5	0
Xiphophora chondrophylla	0.5	0	0	0	0.7	0	0	0.4	0	0	8.8	0.2	0.6	2.7
Zonaria spp.	0.4	0.3	0.1	0	0	0.2	1	0	1.7	0	0	1.3	1.4	9.3
Filamentous browns	0.4	0.3	0	0	0	0.2	0	0	0	0	0	0	0	0

Table 4 (continued). Percentage cover of Macroalgae and encrusting invertebrates on quantitative algal transects in north-eastern Tasmania in 1993 and 1999.

Site	West Penguin	The Piggery (Penguin)	Tee-Tree Pt	Penguin Pt	Outer Sister Is	Goat Is	Goat Is	West Ulverstone	Lilico Beach	Don Heads	Horseshoe reef (Wesley Vale)	Barrel Rock (Low Head)	Low Head (west shore)	Low Head (East shore)
Year	99	99	99	99	99	99	99	99	99	93	93	95	99	93
Depth (m)	5	5	10	10	5	5	10	10	10	5	5	5	5	5
Species														
						Green Algae								
Caulerpa brownii	0	0	0	0	0	0	0	0	0	0	0.8	0	0.8	0.3
Caulerpa flexilis	11.8	5.4	1.5	1	6.5	1.6	5	5.5	0.7	0.1	0.3	0	0	0.4
Caulerpa geminata	0.2	0	0	0	0.2	0	0	0	0	0	0.2	0	0	0.3
Caulerpa scalpelliformis	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0.5
Caulerpa simplisciuscula	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0
Caulerpa trifaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chaetomorpha sp.	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0
Cladophora spp.	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0
Codium lucasii	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0
codium perriniae	0	0	0.2	0	0	0	0	0.9	0	0	0	0	0	0
Codium pomoides	0	0	0	0	0.2	4.8	0	0	0	0	0.1	0	0	0
Codium spp.	0	0	0	0	0	0	0	0	0.1	0	1.1	0	0	0
Fillamentous greens	0	0	2.7	0	0	0	0.5	0	3.3	0	0	0	0	0
						Red Algae								
Areschougia spp.	0	0	0	0	0	0	0	0	18.9	0	0	0	0	0
Ballia callitricha	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0
Ballia scoparia	0	0	0	0	0.2	0	0	0	0	0	0	2.5	0	0
Bangia spp.	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0
Botryocladia obovata	0	0	0.2	0	0	0	0	0	0.5	0	0	0	0	0
Callophyllis rangiferinus	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0
Echinothamnion hystrix	0	0	0	0	0	0.4	0	0	0	0	0	0	1.9	0
Euptilota articulata	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0
Gelidium spp.	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0
Gliosaccion brownii	0	0	0	0.5	0	0	0.3	0	0	0	0	0	0	0
Hemineura frondosa	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0
Laurencia spp.	0	0	0	0	0	0	0.3	0	0	0	0	0.9	0	0
Phacellocarpus peperocarpus	0.6	0.2	0	0	2.2	0	0	0	0	0	0	0	0	0
Plocamium angustum	0	0	0	0	0	0	0	0	0	1.7	0	1.3	0	0
Sonderopelta coriacea	4.5	0.1	0	0	1.2	0	1.2	1.2	0.4	0	0	0	0	0
Sonderopelta/Peyssonelia	0	0	0	0	0	0	0	0	0	0.3	1.1	0	0	0
Thamnoclonium dichotomum	8.3	3.4	5.8	4.2	0.4	4	13.2	14.3	1.1	0	0	0	0	0
Genniculate corralines	35.9	24.9	8.4	7.5	20.8	40.1	16.4	8.7	8.5	0	8.4	0	15	0
Structural corralines	0.3	0	5.9	14.4	0.7	0.6	3.6	8.1	2.5	0	0	0	0	0
Unidentified thallous red alga	0	0	0	0	0	0	0	0	0	0	0.2	9.3	0	0
Filamentous red algae	0.2	0.6	0.2	0.3	2	0	1.8	0	5.3	0	0	0	0.5	0
						Seagrass								
Amphibolis antarctica	0	0	0	0	0	0	0	0	0	0.7	0	0.9	21	0

Table 5. Abundance of invertebrates and cryptic fishes recorded per site on quantitative invertebrate transects conducted in northern Tasmania in 1993 and 1999.

Site	West Penguin	The Piggery (Penguin)	Tee-Tree Pt	Penguin Pt	Outer Sister Is	Goat Is	Goat Is	West Ulverstone	Lilico Beach	Don Heads	Horseshoe reef (Wesley Vale)	Barrel Rock (Low Head)	Low Head (west shore)	Low Head (East shore)
Year	99	99	99	99	99	99	99	99	99	99	99	99	99	99
Depth	5	5	10	10	5	5	10	10	10	5	5	5	5	5
Species														
						Cryptic fishes								
Bovichtus angustifrons	0	0	0	0	0	0	0	0	0	2	1	0	0	0
Norfolkia clarkei	0	0	0	0	0	0	0	0	0	0	1	0	0	2
Heteroclinus perspicillatus	0	0	0	0	0	0	0	0	0	1	0	0	0	0
						Crustaceans								
Pagurid spp.	2	2	0	0	0	0	0	0	0	4	1	0	0	1
Plagusia chabrus	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Trizopagurus strigimanus	1	0	1	0	5	0	0	0	1	0	0	0	0	0
						Echinoderms								
Amblypneustes spp.	0	3	0	0	0	0	0	1	0	0	0	0	1	0
Astrostole scabra	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Austrofromia polypora	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Comanthus tasmaniae	8	0	0	0	0	0	0	0	0	7	1	0	1	0
Comanthus trichoptera	0	0	0	0	0	0	0	0	0	13	12	10	5	12
Conocladus australis	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Coscinasterias muricata	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Echinaster arcystatus	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Heliocidaris erythrogramma	167	215	65	34	415	144	50	97	263	108	337	67	556	133
Holopneustes inflatus	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Nectria ocellata	0	1	7	6	0	1	2	3	1	0	0	0	0	0
Pateriella calcar	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Patiriella brevispina	0	0	0	0	0	2	0	0	0	0	0	1	16	0
Pentagonaster dubeni	0	0	0	0	0	1	0	2	1	0	2	0	0	0
Petricia vernicina	2	0	0	1	0	0	0	1	0	0	0	0	0	1
Plectaster decanus	1	0	2	4	6	2	2	5	0	1	0	0	2	0
Stichopus mollis	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Tosia australis	1	0	0	0	1	6	1	2	2	1	2	17	3	0
Uniophora granifera	0	0	1	0	2	1	1	0	0	0	2	6	1	1
						Molluscs								
Aplysia spp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Astralium squamiferum	0	1	3	1	0	2	0	0	0	0	0	0	0	0
Cabestana tabulata	2	0	0	3	0	0	4	0	0	0	1	0	1	0
Charonia rubicunda	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Chlamys asperimus	0	0	0	1	0	0	0	0	2	0	0	0	0	0
Conus anemone	0	0	0	0	1	0	2	0	1	0	0	0	0	0
Haliotis emma	1	4	6	0	0	7	0	0	0	0	0	0	0	0
Haliotis laevigata	0	1	3	0	4	0	2	0	0	0	0	14	7	0
Haliotis rubra	51	74	99	61	81	44	40	98	27	1	29	51	353	4
Mitra glabra	0	0	0	0	0	0	2	1	1	0	0	0	0	0
Phasianella australis	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Pleuroploca australasia	3	0	2	0	1	2	0	4	0	0	0	0	0	0
Ranella australasia	0	0	1	2	1	1	0	0	0	0	0	0	0	0
Sepia apama	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Thais orbita	4	0	0	0	7	1	1	0	0	4	3	9	0	0
Turbo undulatus	0	0	0	0	0	2	0	0	0	20	0	0	0	0

Table 6. Abundance of fish recorded per site on quantitative fish transects conducted in northern Tasmania in 1993 and 1999.

Site	West Penguin	The Piggery (Penguin)	Tee-Tree Pt	Penguin Pt	Outer Sister Is	Goat Is	Goat Is	West Ulverstone	Lilico Beach	Don Heads	Horseshoe reef (Wesley Vale)	Barrel Rock (Low Head)	Low Head (west shore)	Low Head (East shore)
Year	99	99	99	99	99	99	99	99	99	93	93	95	99	93
Depth (m)	5	5	10	10	5	5	10	10	10	5	5	5	5	5
Species														
Aplodactylus arctidens	0	0	0	0	2	0	0	1	1	0	0	0	0	0
Apogon conspersus	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Atypichthys strigatus	2	10	0	0	0	0	0	0	0	0	0	0	0	0
Bovichtus angustifrons	0	0	0	0	0	0	0	2	0	0	0	2	0	0
Caesioperca rasor	12	0	3	65	0	0	18	17	16	0	11	0	0	0
Cheilodactylus nigripes	1	0	2	7	1	0	3	2	1	7	3	3	2	8
Contusus richei	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Dactylophora nigricans	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Diodon nichthemerus	1	1	0	0	0	1	0	0	0	0	0	1	0	0
Dotalabrus aurantiacus	3	0	0	1	0	0	4	0	0	3	3	8	0	4
Heteroclinus johnstoni	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Latridopsis forsteri	0	0	0	0	0	0	0	0	0	0	0	9	0	0
Melambaphes zebra	0	1	0	7	1	0	1	2	0	0	0	46	0	0
Meuschenia australis	0	0	0	3	2	0	0	0	0	0	0	1	0	0
Meuschenia flavolineata	0	0	1	14	0	0	0	1	0	0	0	0	0	0
Meuschenia freycineti	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Meuschenia hippocrepis	0	1	0	2	1	0	0	1	0	0	0	0	0	0
Neoodax balteatus	0	0	0	0	0	0	0	0	0	19	11	18	0	0
Notalabrus fucicola	5	0	0	2	0	0	0	0	0	1	1	19	1	4
Notalabrus tetricus	54	30	24	41	38	28	25	49	28	25	87	44	34	82
Odax acroptilus	0	0	0	0	0	0	0	0	0	1	0	2	0	1
Parma victoriae	3	4	0	0	0	0	1	2	1	0	1	2	0	5
Pempheris multiradiatus	150	770	1	13	0	2	8	0	5	480	0	0	0	0
Penicipelta vittiger	0	0	0	0	0	0	0	0	0	0	0	4	3	0
Pentaceropsis recurvirostris	0	1	0	1	0	0	0	0	0	0	0	0	0	0
Pictilabrus laticlavius	16	7	8	11	22	11	21	15	22	4	8	7	4	12
Pseudolabrus psittaculus	0	0	0	3	0	0	1	0	4	0	1	0	0	0
Pseudophycis bachus	4	1	0	7	0	0	0	0	3	1	0	0	0	0
Scorpis aequipinnis	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Siphamia cephalotes	0	51	0	0	0	20	0	0	0	0	0	0	171	0
Siphonognathus attenuatus	0	0	0	0	0	0	0	0	0	5	0	15	31	2
Trachinops caudimaculatus	192	533	493	1561	165	153	1331	1746	225	25	242	28	0	9
Upeneichthys vlaminghii	1	0	0	1	0	0	0	0	0	0	0	0	0	1

Notolabrus tetricus (blue-throated wrasse) and *Neoodax balteatus* (rock whiting) were the only species commonly encountered, and although there was a high count of *Siphamia,* this was due to the presence of several schools of recently settled juveniles that are not likely to be a stable component of the fish assemblages on this reef. At the nearby Barrel Rock site, the number of species encountered was significantly higher, possibly reflecting the greater complexity of reef found there.

3.2.4 Discussion

The establishment of a protected area at Low Head has the potential to offer some conservation benefits in addition to acting in the local stock enhancement role proposed by TFIC/TASFA. This area includes good examples of string kelp *Macrocystis angustifolia* forests (a habitat type rare on the north coast) in addition to the unique deep reef sponge gardens associated with the river channel. However, the proposed protected area at Low Head is unlikely to achieve any significant fish stock enhancement or conservation benefits at present given its small size. As the reef extends continuously outside of the proposed boundaries, there is no mechanism to prevent the loss of resident reef fish, and crayfish to fishing on the boundary. The small proposed size guarantees that this loss will be substantial as the scale of daily movements of many resident species is greater than the size proposed for the protected area. As one of the stated aims of this reserve is to protect penguins from netting, an alternative to the proposed "no-take" area may be to establish a gill-net exclusion zone extending around Low Head from Barrel Rock to East Beach. This will provide an enhanced benefit for the penguins while allowing low impact fishing to continue in the area. If the intention of this propagation area is to protect fish stocks as well as protecting penguins, then the proposed boundaries would need to at least be substantially extended to seaward and in a southerly direction. The boundary would best extend seaward to include Middle Bank and the centre of the river channel, following this channel southward to the southern end of Lagoon Bay. This would utilise the natural habitat boundary presented by the deep river channel to minimise loss of fish stocks, and would include the unique deep river channel sponge gardens that are not protected in the present proposal. An extension southward beyond Barrel Rock to Lagoon Bay would enable the use of sand patches as habitat barriers to minimise loss from the propagation area, and also increase its size to something greater than the scale of daily movements of many of the species within it. The inclusion of Barrel Rock in this protected area would significantly enhance its value by adding an area with a rich fish fauna, and an area popular with recreational divers. By extending the boundary to include Lagoon Bay it would also provide a Tamar estuary protected area, as recommended in a recent review of the conservation status of Tasmanian estuaries (Edgar *et al.,* 1997). This extension would include seagrass meadows, enhancing the range of habitats protected, and adding a habitat type thought to provide an important nursery area for many fish species. An associated net exclusion zone encompassing the reef to the north of Low Head, and the reef along the eastern shore to East Beach would also substantially help to prevent loss of fish stocks from the reserve and further protect the penguins that come ashore there.

3.3 Lillico Beach.

3.3.1 Habitat Mapping

Mapping in the proposed protected area at Lillico Beach identified three major habitat types. These were sand, low-flat reef and cobble (Fig. 14), in addition to an extensive intertidal platform (mapped by LIB). The intertidal platform at places extended to over 100 m offshore and was essentially composed of basalt that was usually covered by cobble. This cobble was presumably derived from adjacent river systems as well as from weathering of the conglomerate rock type that is common in this region. This basic formation continues offshore with a very low gradient that descends to only approximately 8 m depth at one kilometre distance offshore. At some stage offshore, the basalt platform is not visible and only cobbles and gravel are evident, although the patchy nature of these bottom types and the gradual transition made identifying definitive boundaries difficult. Therefore the reef/cobble boundaries shown on the map are indicative only. Mixed gravel and cobble extended several kilometres offshore in the area mapped and no transition to sand was evident. Some sand patches were found however, and these are shown on the map at the eastern end of Lillico Beach (Fig. 14). No distinct seagrass beds were identified, although the seagrass *Amphibolis antarctica* was a dominant component of the reef flora in 2-5 m depth in the western section of Lillico Beach.

3.3.2 Qualitative surveys

The macrofauna at Lillico Beach varied slightly between eastern and western sections. At 0-1.5 m depth both areas were similar in composition, with *Acrocarpia paniculata* dominating over *Cystophora moniliformis* and geniculate corallines. At 2-5 m depth the western zone contained mixed patches with either *Acrocarpia* or *Amphibolis* dominating over mixed *Cystophora moniliformis, Cystophora retorta, Sargassum sonderi, Ecklonia radiata* and corallines. In the eastern zone *Ampibolis* was less common, rarely dominant, and *Ecklonia* was increasingly abundant. Below 5 m the assemblages were similar again, and the bottom was dominated by geniculate and encrusting coralline algae. By 9 m there were virtually no brown algae and the flora was composed predominantly of coralline algae and occasional red species. The lack of algae below 9 m appears to be a response to high loadings of fine sediment brought into the area by adjacent rivers. During frequent onshore winds these sediments are readily re-suspended, a process enhanced by the shallow water in this section of coast. The suspended sediments substantially reduce water clarity and therefore limit the amount of light available for algal growth at depths much beyond 9 m.

The low-flat nature of the reef in this region restricts the amount of refuges available for invertebrates and fishes, and few were seen during the qualitative surveys. Those sighted include the urchin *Heliocidaris erythrogramma,* abalone *Haliotis rubra,* blue-throated wrasse *Notolabrus tetricus* and senator wrasse *Pictilabrus laticlavius*.

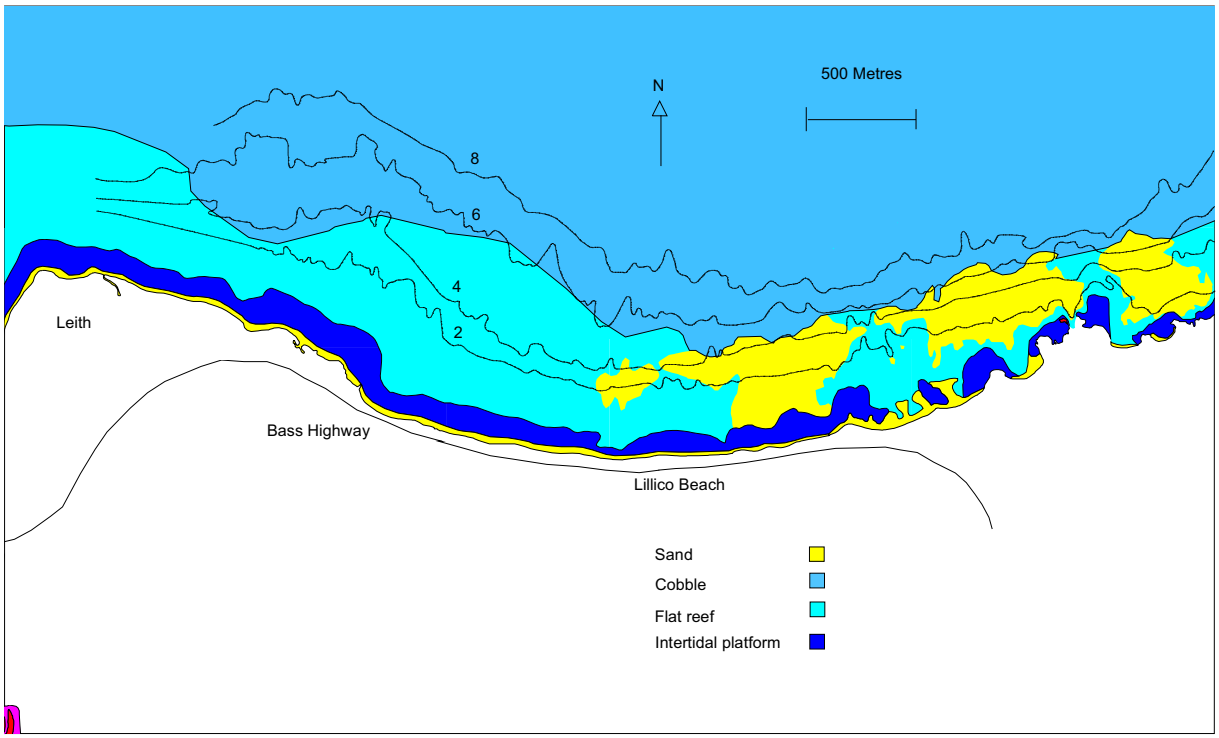

Fig. 14. Detailed habitat map for the coastline adjacent to the proposed Lillico Beach Marine Propagation Area. Depth contours are given with depth in metres relative to the low tide mark as shown by the seaward extension of the intertidal platform.

3.3.3 Quantitative surveys

Only one quantitative survey was undertaken at Lillico Beach, and that was at 10m depth. Low visibility associated with onshore winds encountered during the survey period prevented any surveys conducted at 5 m at this location. The results at the 10m site highlight the simple community structure present at Lillico Beach, particularly for macroalgae and invertebrates (Tables 4 & 5). Brown algae comprised only 7% cover, with the red algae *Areschougia* sp. the most abundant species recorded. A notable feature was the relatively high proportion of geniculate coralline algae present, a characteristic feature of this section of the north coast. Invertebrate numbers were low, with the urchin *Heliocidaris erythrogramma* and the abalone *Haliotis rubra* the only common species present. The fish community was composed of *Notolabrus tetricus* (blue-throated wrasse), *Caesioperca rasor* (barber perch), *Pictilabrus laticlavius* (senator wrasse), and schooling *Trachinops caudimaculatus* (hulafish) in moderate numbers (Table 6), and was characterised by the low number of species encountered, a typical feature of north coast basalt reefs that lack available refuges for many species.

3.3.4 Discussion

The proposed Lillico Beach protected area contains a section of coastline typical of that found along the central north coast, with shallow low-flat reef often covered with cobble and gravel. A reserve at this location has some merit as it would protect an example of these habitat types, however, it is unlikely to offer substantial conservation or stock enhancement benefits. This is because the flat nature of the reef and cobble here lacks an availability of shelter and refuges necessary to maintain sizeable populations of many species of invertebrates and fishes. If a reserve was to be established, the current boundaries are probably adequate to provide some protection for resident species, given that there are no suitable alternative habitat boundaries (such as reef to sand interfaces) in this area to which the proposed boundary could be moved. If the main intention of this reserve is to provide protection to penguins coming ashore at Lillico Beach, an alternative to the proposal is to prevent the use of nets in this area, while allowing low impact fishing to continue.

3.4 Three Sisters-Goat Island

3.4.1 Habitat Mapping

Mapping within the proposed Three Sisters-Goat Island protected area revealed three major habitat types. These were reef, sand, and cobble/gravel (Fig. 15). The reef was in many respects similar to Lillico Beach, with a broad intertidal platform, extending subtidally with a gradual slope. It does differ however, in that some areas were more eroded than others due to differing rock types, with the less eroded areas providing the islands and a moderate amount of physical structure on the reef. The islands and reef appear to be generally of conglomerate origin, and this differs from the basalt found at Lillico Beach. This reef, although well developed structurally, lacked crevices, and therefore the number of refuges available for invertebrates and fishes was limited.

At some distance offshore the reef graded to cobble and gravel, but like Lillico beach, a broad transition zone was present and the reef/cobble boundary shown on the map is only indicative. Patches of more solid reef are found scattered throughout the cobble area, and likewise cobble in the reef area. A substantial amount of the area nominated for the propagation area is sand, a substrate that essentially fringes the intertidal zone from Goat island to Penguin Point, greatly limiting the amount of solid reef that would be protected under the current proposal.

3.4.2 Qualitative surveys

The macroalgal community differed slightly throughout the area examined as the outer Sisters are subject to more wave exposure and have steeper gradients than the remaining coastline. At the outer Sister between 0-2 m depth there was a mixed flora of *Acrocarpia paniculata, Cystophora xiphocarpa, Macrocystis angustifolia, Melanthalia obtusata, Halopteris paniculata* and geniculate coralline algae. Between 4-6 m, the flora was similar but with *Acrocarpia* dominant and *Ecklonia* present. Below 6 m there was virtually no brown algae and the reef was dominated by *Caulerpa flexilis* and *Thamnoclonium dichotomum* (a red algae with associated commensal sponge) to approximately 10 m where *Thamnoclonium* and sponges were the dominant cover. On the remaining coastline where the reef is more gradual and more subject to sediment re-suspension, the flora is similar to the Outer Sister to depths of 4 m, but below this there is very little cover of macroalgae. The most common group below 4 m were geniculate coralline algae. The abundance of geniculate corallines on this coastline is a unique feature and appears to be due to a higher tolerance than other algae to the high sediment loads found in this area. Like Lillico Beach, a combination of low aspect reef, high sediment inputs and frequent onshore winds appears to have heavily influenced the algal species composition and depth distributions. This is presumably due to light attenuation by sediments inhibiting growth, and by the smothering of newly developing plants by sediments. This feature is particularly notable at the Three Sisters-Goat Island area due to the substantial amount of sediments deposited into adjacent waters by Tioxide, a heavy industry that operated until recently, 12 kilometres to the west of this area. The characteristically colored Tioxide sediments were observed at most locations surveyed, and can be seen discolouring the inshore zone following re-suspension by seas generated by strong onshore winds.

The distribution of fish and invertebrates was particularly patchy in this area with patterns of abundance related more to patches of structure with available shelter than to depth. The urchin *Heliocidaris ertyhrogramma* and abalone *Haliotis rubra* were moderately common in these areas, and occasional large aggregations of spider crabs (*Leptomithrax gaimardii*) were also observed. These aggregations each contained many thousands of crabs and were concentrated on the outer reef areas.

Common fishes included *Notolabrus tetricus* (blue-throated wrasse), *Notolabrus fucicola* (purple wrasse), *Pictilabrus laticlavius* (senator wrasse), *Trachinops caudimaculatus* (hulafish), *Cheilodactylus nigripes* (magpie perch) and *Caesioperca rasor* (barber perch).

3.4.3 Quantitative surveys

The quantitative macroalgal surveys in this area revealed the exceptionally low cover of macroalgae found at both 5 m and 10 m depth (Table 4). Very few species were recorded at each site and the flora was almost always dominated by geniculate coralline algae, providing a floristic structure not recorded elsewhere and one that appears related to high levels of turbidity. The one site with a moderate algal cover was the outer Sister, where it appears that the offshore position, coupled with a steep gradient provides some refuge from the sediment loads inshore. At this site at 5m, *Acrocarpia, Halopteris paniculata, Sargassum sonderi,* and *Zonaria* spp. were moderately common, but approaching the lower range of their depth distribution. The invertebrates *Haliotis rubra* (blacklip abalone) and *Heliocidaris erythrogramma* (common urchin) were common to abundant at all sites, and small numbers of the greenlip abalone *Haliotis laevigata* and Emma's ear shell *Haliotis emma (= scalaris)* were also present at some sites (Table 5). The fish community was usually dominated by *Notolabrus tetricus* (blue-throated wrasse), *Trachinops caudimaculatus* (hulafish), *Caesioperca rasor* (barber perch) and *Pictilabrus laticlavius* (senator wrasse) but appeared to be limited by the availability of suitable habitat (Table 6). At Penguin Point, a site with moderate crevice development, other reef species were also common, including *Cheilodactylus nigripes* (magpie perch), *Melambaphes zebra* (zebrafish), *Meuschenia flavolineata* (yellowtail leatherjacket), and *Pseudophycis bachus* (red cod).

3.4.4 Discussion

The proposed protected area at the Three Sisters-Goat Island Nature Reserve has a number of positive features, including proximity to a terrestrial nature reserve, the inclusion of several notable geomorphological features (the islands), and a substantial offshore extension in the eastern sector, providing protection for a relatively large area of cobble and gravel seabed, a habitat common along the central north coast. The large area of sand inshore however, means that very little solid reef at intermediate depths would be included in the current proposal, reducing its value for fish stock enhancement and for conservation. As more substantial reef exists to both the west and east of the current proposal, it is recommended that the suggested boundaries be extended at least one kilometre west to Tea Tree Point to include the more extensive reef habitat found between here and Penguin Pt, and also extended at least one kilometre east to buffer the reef at Goat Island from the impacts of fishing along the protected area boundary. The reef in this area has substantially more physical structure than that found at Lillico Beach and is consequently likely to be of more use in enhancing resident fish stocks, particularly if a sufficient amount of reef is eventually included in the proposal. While the current proposal does offer some local stock enhancement benefits, the associated conservation benefits (other than to penguins) are substantially compromised by the extent of industrial pollution that appears to have heavily impacted this site, such that the marine communities present are in no way representative of those found in less polluted sections of this coast.

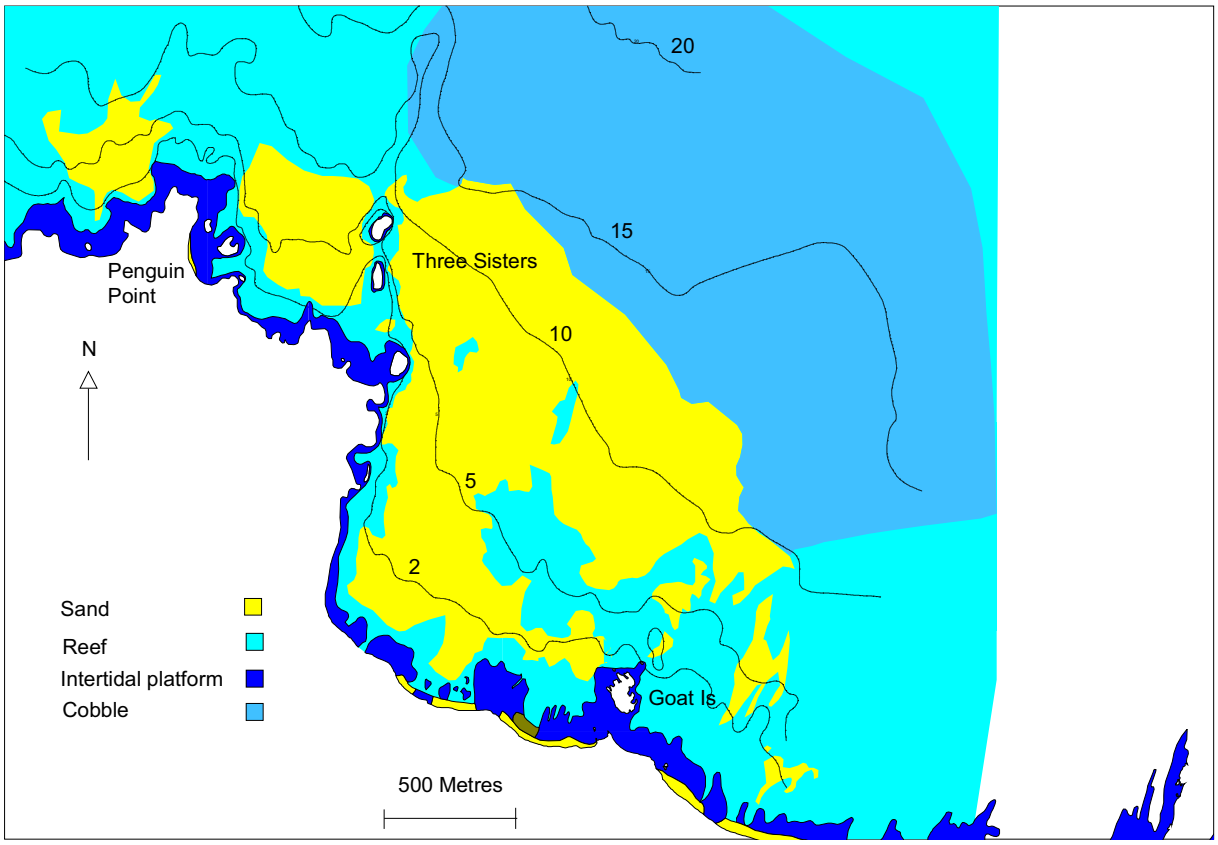

Fig. 15. Detailed habitat map of the coastline adjacent to the proposed Three Sisters-Goat Island Marine Propagation Area. Depth contours are given with depth in metres relative to the low tide mark as shown by the seaward extension of the intertidal platform

Constant re-suspension of fine sediments originating from Tioxide in the near shore zone has led to a marked reduction in the subtidal flora in this region (Ritz *et al*. 1985), which from this survey at the Three Sisters/Goat Island area appears to be particularly notable at depths greater than 5m. This is in no doubt compounded by additional sediments contributed by adjacent rivers as a result of land clearing.

3.5 Waterhouse

3.5.1 Habitat Mapping

Mapping in the Waterhouse region of Tasmania's north-east revealed three major habitat types, complex reef, sand and seagrass (Fig. 16). The reef component was composed of two distinct rock types, dolerite and granite. The dolerite reefs extended from South Croppies Point eastwards to approximately one kilometre before the tip of Waterhouse Point, and included the reef at Barrett Rocks, Little Waterhouse Island and Waterhouse Island. The granite reefs extend further eastward. Generally the dolerite reef was moderately to highly structured, with good crevice development, whereas the granite reef tended to be less structured, but with occasional areas of high relief. There appears to be a substantial amount of dolerite reef in this area, particularly along the western shore of Waterhouse Island and extending as a continuous band of reef from North Croppies Point five kilometres eastwards to Blizzards Landing, and offshore to Little Waterhouse Island and Barrett Rocks. Further reef possibly exists to the west of Barrett Rocks and Waterhouse Island but strong winds prevented surveys in this area and no shallow reef was evident from aerial photographs to allow targeted ground surveying. The reef at North Croppies Point, Barrett Rocks and Little Waterhouse Island extends into depths beyond 15 m, and on the western shore of Waterhouse Island to depths in excess of 30 m in places. These depths are substantially greater than that normally found inshore on the northern Tasmanian coastline. The granite reefs to the east of this area are shallower and tend to be far less distinctive, occurring as small patches distributed throughout the seagrass beds and along the sandy coastline to the east of Waterhouse Point. As these reefs were often low, flat and patchy, it is possible that a moderate amount of this reef type exists within the area shown as seagrass to the east of Little Waterhouse Island and Waterhouse Point, but that these areas have not been mapped. This is because this reef type is indistinguishable from seagrass on aerial photographs and usually also from sounder outputs. The only reliable method of determining the presence of this type of reef is visual identification by viewer or video, and where reef patches were encountered they are shown on the map.

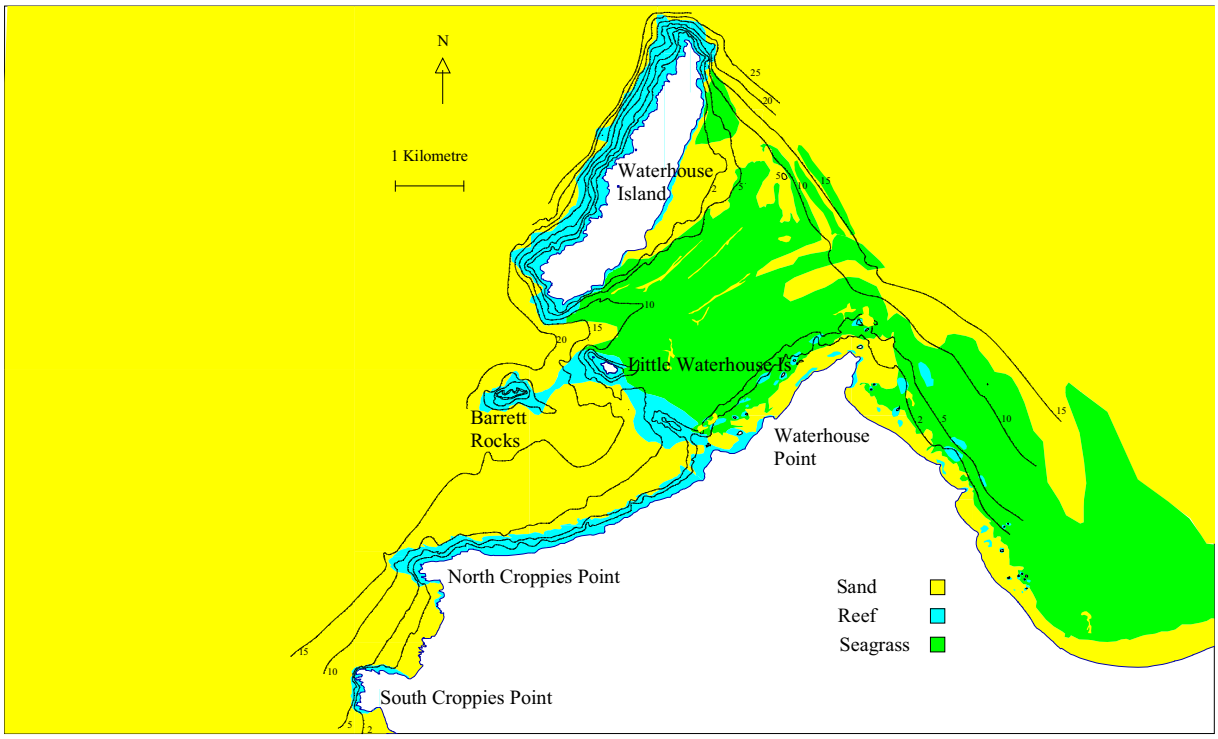

Fig. 16. Habitat map of the Waterhouse region of north-eastern Tasmania. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

Patch reefs appear to be more abundant to the east of Waterhouse Point but flat reef patches are known to also occur within Waterhouse Passage (Rick Officer, Pers. Comm.). The most notable feature of this region is the extensive cover of seagrass that extends from Waterhouse Island eastwards to Tomahawk and beyond. These extensive beds appear to occur in response to the shelter provided from the prevailing westerly winds by the islands, reef ridge and Waterhouse Point. Sand has built up in the lee of these barriers, allowing seagrass to become established in an extensive shallow basin. These dense seagrass beds are dominated by *Posidonia australis,* particularly in depths greater than 5 m. At these depths however, occasional patches of *Amphibolis antarctica* are also found, and sparse patches of *Heterozostera tasmanica* fringe the main beds. This fringing area often extends from 16m, the maximum depth of the main beds, to approximately 18 m. The fringing beds are not mapped due to their sparse nature. In waters shallower than 5 m the most dominant species is *Amphibolis antarctica,* and in waters shallower than 2 m this was the only seagrass present. As found in other areas of the north coast, *Amphibolis* is also a common component of the flora on low flat reef, particularly in the sheltered waters to the east of Waterhouse Point. Sand was the other main habitat type in the area. This region contains areas of sandy sea-bed extending from depths beyond 35 m to the extensive beaches to the west of Croppies Point, and to the east of Waterhouse Point, including a small beach on the eastern shore of Waterhouse Island.

3.5.2 Biological surveys

This area was surveyed in 1993 as part of a wider survey of potential marine reserve locations in Bass Strait (Barrett and Edgar, 1993) and also during the Iron Baron oil spill (Edgar and Barrett, 1999) and the results are discussed in some detail in those reports. However, surveys were restricted to 5 m depth and no information was recorded from greater depths for comparison with adjacent areas, or for a better understanding of the area itself. Therefore an additional three sites were surveyed in 1999 at 10 m and qualitative observations at greater depths were also included at these sites. The algal composition was dominated at most depths between 0-20 m by *Acrocarpia paniculata* and *Seirococcus axillaris,* with a mixed canopy of *Cystophora* species , *Sargassum* species, and *Carpoglossum confluens* comprising the remaining flora (Table 7). One notable feature was the virtual absence of *Ecklonia radiata* from the flora, suggesting the mix of wave energy and currents in this region were insufficient to maintain this normally common species. The exception to this was the northern end of Waterhouse Island where very strong tidal currents maintain dense *Ecklonia* forests to approximately 30 m depth, below which a rich invertebrate fauna dominated by sponges was found. In all areas examined, the algal cover at 10m and deeper was usually substantial, often approaching 100%, although at North Croppies Point density was significantly reduced below 13 m depth. There was no evidence of sediments restricting algal growth in the manner found on the central north coast, or of the urchin barren zones found on the north-east coast and eastern Bass Strait islands.

The dominant invertebrates at most sites and depths were the urchin *Heliocidaris erythrogramma* and the abalone *Haliotis rubra,* with the featherstar *Comanthus trichoptera* abundant at high current sites such as Little Waterhouse Island, and the greenlip abalone *Haliotis laevigata* common on the deeper sections of the reef (Table 8) and on isolated patches of low flat reef amongst the seagrass beds in Waterhouse Passage (Rick Officer, Pers. Comm.). One feature of the invertebrate surveys was the virtual absence of juvenile rock lobsters and the presence of some large adults, indicating that the habitat is suitable for growth of lobsters but that recruitment levels in the area are very low. An additional observation is the complete absence of the urchin *Centrostephanus rodgersii,* a species now abundant in north-eastern Tasmanian waters, suggesting that the hydrology of the area is such that East Australian Current waters carrying the larvae of this species rarely enter this section of Bass Strait.

The fish community within the area was characterised by having a substantially higher species richness per transect than that found for the central north coast (Three Sisters-Goat Island, Lillico Beach area), with an average of 17 species per site compared with 10, and this increase in the number of species per site was usually accompanied by a similar increase in abundance. The addition of sites at 10 m contributed little extra information on the fish communities present in the area over that described by Barrett and Edgar (1993), with the fauna dominated by *Notolabrus tetricus* (blue-throated wrasse), but also containing substantial numbers of other reef dwelling species at each site (Table 9). Many of the more abundant species are those with a Tasmanian distribution restricted predominantly to the north coast. These include *Enoplosus armatus* (old wife), *Cheilodactylus nigripes* (magpie perch), *Melambaphes zebra* (zebrafish), *Meuschenia flavolineata* (yellowtail leatherjacket), *Meuschenia hippocrepis* (horseshoe leatherjacket), *Odax acroptilis* (rainbow fish), and *Parma victoriae* (scaly fin), highlighting the potential for this area to adequately protect a range of species and habitats typical of those found at other locations on the Tasmanian north coast.

3.5.3 Discussion

The waters around Waterhouse Island and Waterhouse Point are ideally suited for the establishment of a representative marine protected area for the eastern section of the Boags bioregion on Tasmania's north coast. This location offers a wide variety of typical north coast habitats within a small geographical area, including reef ranging from 0-35 m depth with a variety of exposures and current strengths, through sand from 0-35 m depth, to extensive seagrass beds. The area also includes a mix of sandy beaches and rocky coastline. An additional benefit is that the reef development is substantial, with complex structure, providing refuge for a wide variety of species representative of this region, and often in abundances significantly greater than found on the less structured reefs on the central north coast. The seascape allows for an interconnectedness of habitats within the one protected area, an important feature, especially for species whose life histories span several adjacent habitat types. Due to the remoteness of this location, there is the potential to establish a reserve of biologically meaningful size such that most resident species will be afforded protection. It also has the advantage that a number of distinct habitat boundaries within the area can be used to effectively protect some vulnerable species from loss across defined borders.

Table 7. Percentage cover of Macroalgae and encrusting invertebrates on quantitative algal transects in the vicinity of the Waterhouse region of north-eastern Tasmania, and the Rocky Cape region of north-western Tasmania in 1993 and 1999. Table continues next page.

Site	Rocky Cape	Anniversary Pt (west)	Anniversary Pt (west)	Sisters Beach (west)	Sisters Rocks	Sisters Is (east)	Boat Harbour	Table Cape	North Croppies Pt	North Croppies Pt	Little Waterhouse (north)	Waterhouse Is (west)	Waterhouse Is (west)	Waterhouse Bay	Cape Portland
Year	92	92	99	99	92	99	92	92	92	99	92	92	99	99	92
Depth (m)	5	5	10	10	5	10	5	5	5	10	5	5	10	10	5
Species															
							Invertebrate cover								
Bryozoans (soft)	0	0	0.3	1.5	0	5.7	0	0	0	0.7	0	0	0	0	0
Bryozoans (hard)	0	0	1.5	0.5	0	0.3	0	0	0	0	0	0	0	0	0
Sponges	0	0	0.8	0.8	0	0	0	0	0	0	0	0	0.4	0	0
							Brown algae								
Filamentous browns	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0
Acrocarpia paniculata	7.1	18.8	4.2	4.9	36.5	0.5	40.1	29.7	57.1	27.1	79.6	46.4	22.4	13.5	26.3
Carpoglossum confluens	8	0.2	0	0	0.8	3.4	0.5	0.2	1.1	9.9	3.7	0.2	10.3	6.2	0
Caulocustis uvifera	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0.9	2.5
Caulocystis cephalornithos	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0
Cystophora expansa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.4
Cystophora monilifera	0.4	0	0	0	0	0	0	0	1.4	0	2.8	2.9	0	1.2	0
Cystophora moniliformis	1.3	0	0	0	4.2	1.1	10	1.8	19.7	6.5	6.6	4.6	0	2.4	8.1
Cystophora platylobium	0.8	0	0	0	4.4	0	0.1	3	0	0	0	0	0	0	0
Cystophora retroflexa	19.8	4.7	0	7.3	1.8	3.2	5.6	2.4	1.9	0.4	0	0	0.2	8.6	14.7
Cystophora subfarcinata	0	0	0	0	0.2	0	1.9	0.9	3.6	0	0	2.5	0	0	2.1
Dictyopteris muelleri	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	8.6
Dictyota sp.	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0
Dictyota dichotoma	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0
Ecklonia radiata	29.8	0.5	5.3	15.9	16.1	54.6	4.8	43.4	0	0	0.1	0.2	0	0	0
Halopteris spp.	0.4	0	0.5	0	0.3	0.4	0.5	1	0.1	0	0.1	8.1	0.6	0.6	0
Homeostrichus sinclairii	0	0	0	0	0	0	0	0	0	0	0	0	15.3	0	0
Macrocystis angustifolia	0	0	1.4	0	0	2.4	0.4	0	0	0	0	0	0	0	0
Perithalia cordata	0.3	1.9	0	0.9	5.9	0.4	3.9	2.2	1.1	2.1	1.2	3.4	7.2	0	2.5
Phyllospora comosa	1.6	0	0	0	19.1	7.5	0	13.4	0	0	0	5.6	0	0	0
Sargassum decipiens	16.3	3.2	0	9.3	0.6	0	6.9	0.8	0	0	0	0	0	0	0
Sargassum fallax	0	0	1.7	0.3	0	2.6	0	0	0	3.8	0	0	1.1	0	1.1
Sargassum heteromorphum	0	0.3	0	0.4	0	1.3	0	0	0	0	0	0.4	0	0	0.4
Sargassum lacerifolium	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0
Sargassum sonderi	0	0	1	4.1	0	4	0	0	0	11	3	0	10.4	6.8	1.5
Sargassum spp.	1.6	1.4	0.4	2.1	2.8	1.4	0.9	1.8	1.9	0	0.3	5.9	0	0	0
Sargassum varians	5.8	2.9	1.4	1.4	1.7	0.6	0.5	0	4.6	0	0.7	8.2	0.5	0	10.1
Sargassum verruculosum	1.6	0	0	0.3	0	0	0.2	0	0	0	0	0	0.8	0	1.1
Scaberia agardhii	0	0	0	0	0	0	0	0	0	0	0	0	0	1.9	0
Seirococcus axillaris	0	0.2	0	7.2	0	0	0	0	36.1	16.4	29.8	6.1	28	7.8	13.8
Sporochnus spp.	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Xiphophora chondrophylla	0	0	0	0	0	0.7	0	0	0	0	0	0	0	3.3	4.3
Zonaria spp.	4.4	9.7	1.2	4.1	7.3	0.7	5.3	1.4	2.5	1.7	1.4	2	4.1	9.2	11.2

Table 7 (continued). Percentage cover of Macroalgae and encrusting invertebrates on quantitative algal transects in the vicinity of the Waterhouse region of north-eastern Tasmania, and the Rocky Cape region of north-western Tasmania in 1993 and 1999.

Site	Rocky Cape	Anniversary Pt (west)	Anniversary Pt (west)	Sisters Beach (west)	Sisters Rocks	Sisters Is (east)	Boat Harbour	Table Cape	North Croppies Pt	North Croppies Pt	Little Waterhouse (north)	Waterhouse Is (west)	Waterhouse Is (west)	Waterhouse Bay	Cape Portland
Year	92	92	99	99	92	99	92	92	92	99	92	92	99	99	92
Depth (m)	5	5	10	10	5	10	5	5	5	10	5	5	10	10	5
Species															
							Green algae								
Caulerpa remotifolia	0	0	0	2.4	0	0	0	0	0	0	0	0	0	3	0
Caulerpa annulata	0.1	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0
Caulerpa brownii	0.7	0.3	0.2	0	0	0	0.9	0	0	0	0	4.3	0.4	1.4	0
Caulerpa cactoides	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3
Caulerpa flexilis	0.3	1.4	1.2	1.6	0.6	1.4	0.3	0	0	0	0.2	2.6	0	0.2	0.6
Caulerpa flexilis var. muelleri	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0	0
Caulerpa geminata	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0
Caulerpa longifolia	0.3	0	1.6	1.1	0	0	0	0	0	0	0	0	0	0	0
Caulerpa obscura	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Caulerpa scalpelliformis	0	0	0.3	0	0	0	0	0	0	0.6	0	0.2	0	0	0
Caulerpa simplisciuscula	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0
Caulerpa trifaria	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0
Caulerpa vesiculifera	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0
Codium lucasii	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0
Codium pomoides	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0.2	0
Codium spp.	0	0.4	0.7	0	0	0	0	0	0	0.1	0	0	0	0.3	0
Dictyosphaeria serica	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0.2	0
							Red algae								
Ballia callitricha	0	0	0	0	0.2	0	0	0	0	0	0.2	0	0	0	0
Botryocystis browni	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0
Callophyllis lambertii	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0
Callophyllis rangiferinus	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0
Champia viridis	0	0	0	1.8	0	0	0	0	0	0.2	0	0	0	0	0
Dictymenia harveyana	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0
Dictymenia tridens	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0
Echinothamnion hystrix	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3	0
Euptilota articulata	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0
genniculate corralines	0	0	13.2	15.8	0	1.7	0	0	0	1.8	0	0	0	4.2	0
Jeannerettia lobata	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0
Laurencia elata	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0
Laurencia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5	0
Melanthalia obtusata	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0
Phacellocarpus peperocarpus	0	0.4	0	0	0	0	0	0.2	0.8	0	0.7	1.1	5.9	0	0
Plocamium angustum	0	0	0	0.2	0.1	0	0	0	1.3	1.6	0.9	2.6	8.3	0	0
Plocamium cartilagineum	0	0	0	0	0	0	0	0	0	0.9	0	0	1.2	0.2	0
Plocamium costatum	0	0	0	0	0	0	0	0	0	0.8	0	0	0	0	0
Plocamium dilatatum	0	0	0	0	0	0	0	0	0	0	0	0.3	0.9	0	0
Plocamium mertensii	0	0	0	0	0.3	0	0	0	0	0	1	0	0	0	0
Plocamium potagiatum	0	0	0	0	0	0	0	0	0	1.7	0	0.3	2.3	0	0
Pterocladia capillacea	0	0	0	0	0	0	0	0	3.2	0	0	0	0	0	0
Ptilonia australicum	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0	0
Sonderopelta coriacea	0	0	1	0.1	0	0.4	0	0	0	0.1	0	0	0.4	0	0
Sonderopelta/Peyssonelia	0.2	1.4	0	0	0.3	0	0	0	0	2.9	0	0	0	0.8	0
Thamnoclonium dichotomum	0	0	1.3	0.4	0	0	0	0	0	0	0	0	0	0	0
Structural corallines	0	0	0	0	0	0.2	0	0	0	0	0	0	0	0	0
Geniculate corallines	0	0.1	0	0	0.1	0	4.2	0.3	1.1	0	1.8	5.2	0	0	7.7
Filamentous red algae	0	0	0.3	0	0	0	0	0.3	0	12.9	0	0.5	0	0.9	0
Unidentified thallous reds	0	0.1	0	0	0	0	0	0	0	0	1.4	0.4	0	0	0
							Seagrass								
Amphibolis antarctica	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0

Table 8. Abundance of invertebrates and cryptic fishes recorded per site on quantitative invertebrate transects conducted in the vicinity of Rocky Cape and Waterhouse Point in Tasmania in 1993 and 1999.

Site	Rocky Cape	Anniversary Pt (west)	Anniversary Pt (west)	Sisters Beach (west)	Sisters Rocks	Sisters Is (east)	Boat Harbour	Table Cape	North Croppies Pt	North Croppies Pt	Little Waterhouse (north)	Waterhouse Is (west)	Waterhouse Is (west)	Waterhouse Bay	Cape Portland
Year	92	92	99	99	92	99	92	92	92	99	92	92	99	99	92
Depth	5	5	10	10	5	10	5	5	5	10	5	5	10	10	5
Species															
							Cryptic fishes								
Aetapcus maculatus	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Bovichtus angustifrons	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0
Gnathanacanthus goetzii	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0
Heteroclinus johnstoni	0	0	0	0	2	0	0	1	4	0	1	1	0	0	0
Scorpaena papilosa	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1
Trianectes bucephalus	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0
							Crustaceans								
Jasus edwardsii	0	0	0	0	0	0	3	0	1	0	0	0	0	0	0
Nectocarcinus tuberculatus	1	1	0	0	2	0	0	4	2	0	0	0	0	0	0
Grey hermit crabs	17	3	3	0	3	0	17	13	1	2	3	0	2	0	0
Plagusia chabrus	1	0	0	0	6	0	3	12	2	0	4	7	3	0	2
Trizopagurus strigimanus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
							Echinoderms								
Amblypneustes spp.	0	0	6	0	0	9	0	0	0	2	0	0	2	0	4
Austrofromia polypora	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Comanthus tasmaniae	0	0	2	0	0	0	0	0	0	1	0	0	5	3	0
Comanthus trichoptera	4	16	0	0	13	12	8	1	116	9	569	1	218	8	43
Coscinasterias muricata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Echinaster arcystatus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Goniocidaris tubaria	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0
Heliocidaris erythrogramma	329	588	310	451	299	375	184	119	197	87	214	20	303	41	354
Holopneustes inflatus	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0
Holopneustes porossimus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Nectria ocellata	0	1	0	1	0	2	0	1	1	4	5	1	7	2	0
Patiriella brevispina	0	0	0	0	0	0	0	0	4	16	0	1	0	3	0
Pentagonaster dubeni	1	0	0	0	6	0	0	1	0	0	1	0	3	1	2
Petricia vernicina	1	0	10	0	0	3	1	0	1	5	0	0	5	0	1
Plectaster decanus	9	5	8	1	4	8	2	0	9	15	1	2	7	3	2
Smilasterias multipara	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Stichopus mollis	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Tosia australis	10	6	0	0	27	0	12	2	13	0	6	2	0	2	2
Tosia magnifica	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Uniophora granifera	3	5	1	2	0	4	3	1	0	3	1	1	0	0	0
							Molluscs								
Aplysia spp	0	1	0	0	0	0	2	0	0	0	2	0	0	0	0
Astralium squamiferum	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Cabestana tabulata	0	0	4	0	0	3	0	0	0	0	0	0	0	0	0
Chlamys asperimus	1	0	0	2	0	0	0	0	0	0	0	0	0	0	1
Conus anemone	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Haliotis emma	0	6	0	0	0	0	0	0	0	0	0	0	0	0	3
Haliotis laevigata	0	4	5	8	0	0	0	0	0	23	0	0	4	17	3
Haliotis rubra	202	29	174	74	58	80	41	177	8	26	1	34	44	11	10
Mitra glabra	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Penion mandarinus	0	1	0	0	0	0	2	1	0	0	0	0	0	0	0
Phasionella ventricosa	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0
Pleuroploca australasia	5	1	1	0	2	0	9	0	2	0	0	0	0	2	0
Ranella australasia	0	5	0	0	1	0	0	0	0	0	0	0	0	0	0
Thais orbita	1	0	0	0	1	0	23	11	1	0	3	1	1	0	2
Turbo undulatus	4	0	0	0	0	0	15	19	1	0	0	1	0	0	0

Table 9. Abundance of fish recorded per site on quantitative fish transects conducted in the vicinity of Rocky Cape and Waterhouse Point in Tasmania in 1993 and 1999.

Site	Rocky Cape	Anniversary Pt (west)	Anniversary Pt (west)	Sisters Beach (west)	Sisters Rocks	Sisters Is (east)	Boat Harbour	Table Cape	North Croppies Pt	North Croppies Pt	Waterhouse Bay	Little Waterhouse (north)	Waterhouse Is (west)	Waterhouse Is (west)	Waterhouse Is (north)	Waterhouse Pt	Cape Portland
Year	92	92	99	99	92	99	92	92	92	99	99	92	92	99	92	92	92
Depth (m)	5	5	10	10	5	10	5	5	5	10	10	5	5	10	5	5	5
Species																	
Acanthaluteres spilomelanurus	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	10	0
Aplodactylus arctidens	0	0	0	0	0	0	0	0	0	1	0	0	3	0	2	1	0
Aracana aurita	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Atypichthys strigatus	0	0	0	0	0	0	0	0	0	0	20	0	0	8	0	0	0
Bovichtus angustifrons	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Caesioperca rasor	40	136	64	36	15	255	3	5	2	0	1	3	1	33	28	0	0
Cheilodactylus nigripes	5	11	16	5	9	1	17	25	15	2	6	7	27	8	19	18	0
Cheilodactylus spectabilis	0	0	0	0	0	0	0	3	0	0	0	0	1	0	4	0	0
Dasyatis brevicaudatus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dinolestes lewini	0	0	0	0	0	0	0	466	0	1	0	0	0	15	0	0	0
Diodon nichthemerus	0	2	0	0	1	0	2	5	2	0	0	0	0	0	0	0	0
Dotalabrus aurantiacus	4	0	0	7	0	2	0	0	0	1	0	2	2	0	1	16	1
Enoplosus armatus	0	0	0	0	0	0	0	3	5	0	0	0	6	2	11	13	0
Eubalichthys gunnii	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
Forsterygion varium	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Heterodontus portusjacksoni	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0
Hypoplectrodes nigrorubrum	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
Latridopsis forsteri	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
Melambaphes zebra	0	0	0	0	0	0	2	2	0	0	0	6	58	6	9	12	0
Meuschenia australis	8	3	1	1	3	0	3	1	0	5	0	2	6	3	0	5	0
Meuschenia flavolineata	0	2	1	0	0	0	0	0	1	3	0	1	3	1	0	0	0
Meuschenia freycineti	1	2	1	3	0	0	1	3	0	0	0	0	0	0	0	0	0
Meuschenia hippocrepis	1	1	0	0	0	0	0	6	9	2	0	24	21	2	5	11	0
Neoodax balteatus	0	1	8	6	3	3	2	0	0	0	0	36	0	3	0	2	3
Notalabrus fucicola	15	2	0	0	1	0	2	7	0	1	0	6	0	2	0	0	0
Notalabrus tetricus	91	170	39	44	69	16	63	58	113	84	52	116	330	81	167	217	45
Odax acroptilus	1	0	0	0	0	0	0	0	0	0	0	7	1	0	4	4	0
Odax cyanomelas	4	0	0	0	1	1	0	24	4	2	0	10	6	0	21	3	0
Parma victoriae	0	2	7	2	4	1	1	2	9	3	0	4	15	10	3	10	1
Pempheris multiradiatus	107	0	0	0	540	0	1218	486	80	0	100	0	0	50	0	1	0
Penicipelta vittiger	6	0	2	1	6	5	2	9	3	0	0	29	27	0	15	9	2
Pentaceropsis recurvirostris	1	1	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0
Pictilabrus laticlavius	3	4	10	9	8	11	9	4	10	35	35	16	7	36	7	34	2
Pseudolabrus psittaculus	11	18	0	0	7	1	0	2	0	0	0	0	0	0	0	0	0
Pseudophycis bachus	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Raja whitleyi	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scorpis aequipinnis	10	0	0	0	3	0	1	44	16	0	0	2	21	0	3	10	0
Scorpis lineolatus	0	0	0	0	0	0	0	10	0	0	0	0	0	0	4	10	0
Siphamia cephalotes	0	0	0	0	0	0	0	0	0	0	353	0	0	0	0	0	0
Siphonognathus beddomei	41	2	20	3	31	4	4	12	27	9	3	50	10	26	60	83	68
Trachinops caudimaculatus	72	42	448	88	256	1097	97	76	0	0	0	0	0	117	0	0	0
Upeneichthys vlaminghii	3	2	0	18	2	1	4	0	0	4	0	0	0	7	0	1	5
Urolophus paucimaculatus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Any proposal would ideally include the waters around Waterhouse Island to at least one kilometre offshore, providing protection to the entire reef system around the island, including the exposed western shore reefs, sheltered eastern shore reefs and the high current and deep reefs at the northern tip. It would include the seagrass beds in Waterhouse Passage from one kilometre east of Waterhouse Point to the northern tip of Waterhouse Island and westwards to Little Waterhouse Island, protecting examples of *Posidonia, Amphibolis* and *Heterozostera* seagrass beds, as well as protecting the isolated patches of low flat reef found there. Additionally the reef extending from the beach to the south of North Croppies Point through to Little Waterhouse Island and Barrett Rocks including the adjacent sand areas, should be included to protect the substantial section of coastal reef found there, and to provide for easy public access to shoreline sections of a marine reserve. Together, these suggested areas would provide adequate protection to the full range of habitats found within this region, at a meaningful spatial scale, with adequate physical boundaries within the overall area adding to the level of protection against loss to adjacent fished areas. Popular camping and fishing areas are situated to the east of Waterhouse Point, and therefore any substantial extension of a marine reserve in this direction is likely to be unpopular with recreational fishers, however, a one kilometre section of the coast eastwards from Waterhouse Point would ideally be included to add a sheltered embayment to the range of habitats included within the reserve. South Croppies Point is a popular shore fishing location and the inclusion of this smaller section of reef within a reserve proposal would not be appropriate. The protection of North Croppies Point would, however, be an essential feature of a reserve at Waterhouse as it would not only protect part of a continuous shoreline reef system, but would also allow easy shore access by divers and snorkellers to a section of highly structured reef with a deep offshore extension and diverse fish community.

3.6 Rocky Cape

3.6.1 Habitat Mapping

The section of coastline from Boat Harbour Beach to the Rocky Cape township was mapped in detail for distances to one kilometre offshore, with the exception of Rocky Cape itself where greater distances were investigated to fully map the outer reef (Figs 17 to 24). This mapping revealed only two distinct habitat types, sand and complex reef. With the exception of Sisters Beach and smaller beaches near Anniversary Point, most of this coastline consists of a rocky shoreline of highly folded metamorphic quartzite that extends offshore as moderately-structured reef, with moderate cave and crevice development. The reef at most locations extends between 100 m to 200 m offshore and into approximately 10 m of water (Figs 17 to 22), with several areas having substantially more reef development, including Shelter Point at Boat Harbour Beach, Sisters Island, and the northern extension of Rocky Cape. Two particularly notable reef sections occur in the area examined and these are Outer Reef offshore from Rocky Cape (Fig. 24) and the section of reef around Sisters Island (Fig. 23).

Both of these areas have reef that extends to depths below 25 m, with a good degree of representation of reef at most depths over the range from 5-20 m. The area known as Outer Reef has a distinct pinnacle on the south-eastern corner that is exposed at low tide. Outer Reef and the northern section of the Sisters Island reef are both subject to strong tidal currents. The deeper sections of reef, particularly those below 20 m exposed to these currents are covered in extensive sponge gardens, and with these particularly well developed on the northern section of Sisters Island.

No distinct seagrass beds were found in the area mapped, although sparse *Heterozostera beds* were observed growing on the sand at depths between 10 m & 18 m in most of this region, particularly offshore from Sisters Beach. The seagrass *Amphibolis antarctica* was also present at a number of locations but was always found growing on reef at approximately 3-5 m depth, and was present as part of a larger flora, with macroalgal species also common. *Amphibolis* was mostly found on the reefs fringing the shoreline of the western section of Sisters Beach and on similar habitats near Anniversary Point. A small isolated patch was also found on reef near the western Rocky Cape boat-ramp. The remaining habitat type was sand, and this extended seawards from sandy beaches, offshore to depths of approximately 30 m in the area mapped. Mostly this was bare sand, with the exception of the sparse *Heterozostera* beds, however, in depths greater than 30 m in this area a significant invertebrate fauna based around large structural sponges is known to exist (Greilach *et al.* 1995).

3.6.2 Biological surveys

The macroalgal flora within this area varied depending on the degree of exposure to currents and swells. The typical flora had *Acrocarpia* and *Cystophora moniliformis* as dominant species from the immediate subtidal zone to 4 m depth, with *Sargassum varians, Sargassum decipiens, Cystophora retroflexa* and *Ecklonia* common. Below 4 m the proportion of *Ecklonia* increased while *Acrocarpia* decreased, with a similar composition of additional species to that found in shallower waters also present. At most locations the abundance of macroalgae decreased substantially below 10-12 m, with *Thamnoclonium,* geniculate coralline algae and sponges common, and with *Caulerpa* species also conspicuous. Below 14 m most sections of reef were dominated by invertebrates.

At the most exposed reefs such as Outer Reef, Rocky Cape, and Sisters Island, *Ecklonia* and *Phyllospora* were the predominant species, with *Phyllospora* abundant from approximately 3 m to 8 m and *Ecklonia* from 5 m to 12 m. At these locations *Macrocystis angustifolia* was also a common component of the flora from 2 m to 10 m, and was often the dominant species in the immediate subtidal zone. Quantitative algal data (Table 7) indicates substantial differences between this section of coast and the Waterhouse region, with *Ecklonia* a common species at Rocky Cape and virtually absent at Waterhouse. This major community shift is presumably driven by differences in exposure to prevailing westerly winds and swells, with Rocky Cape more exposed than Waterhouse.

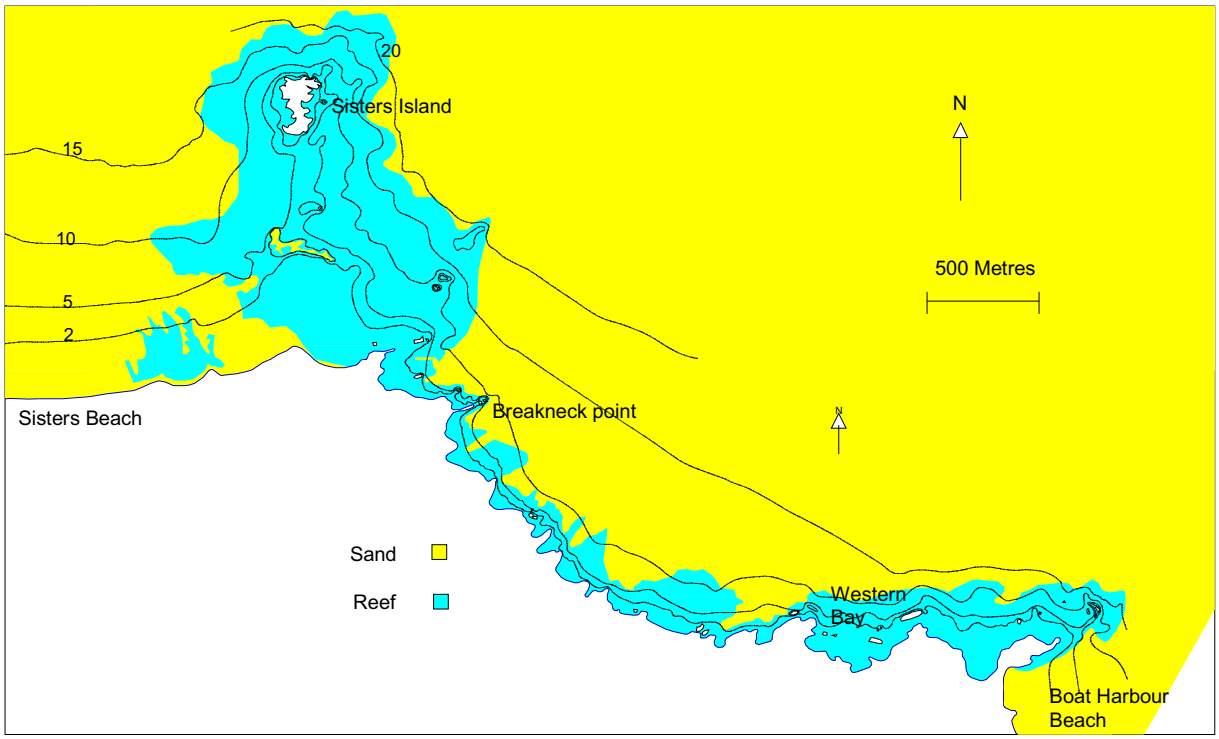

Fig. 17. Map of marine habitats found between Boat Harbour Beach and Sisters Beach on the Tasmanian north-west coast. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

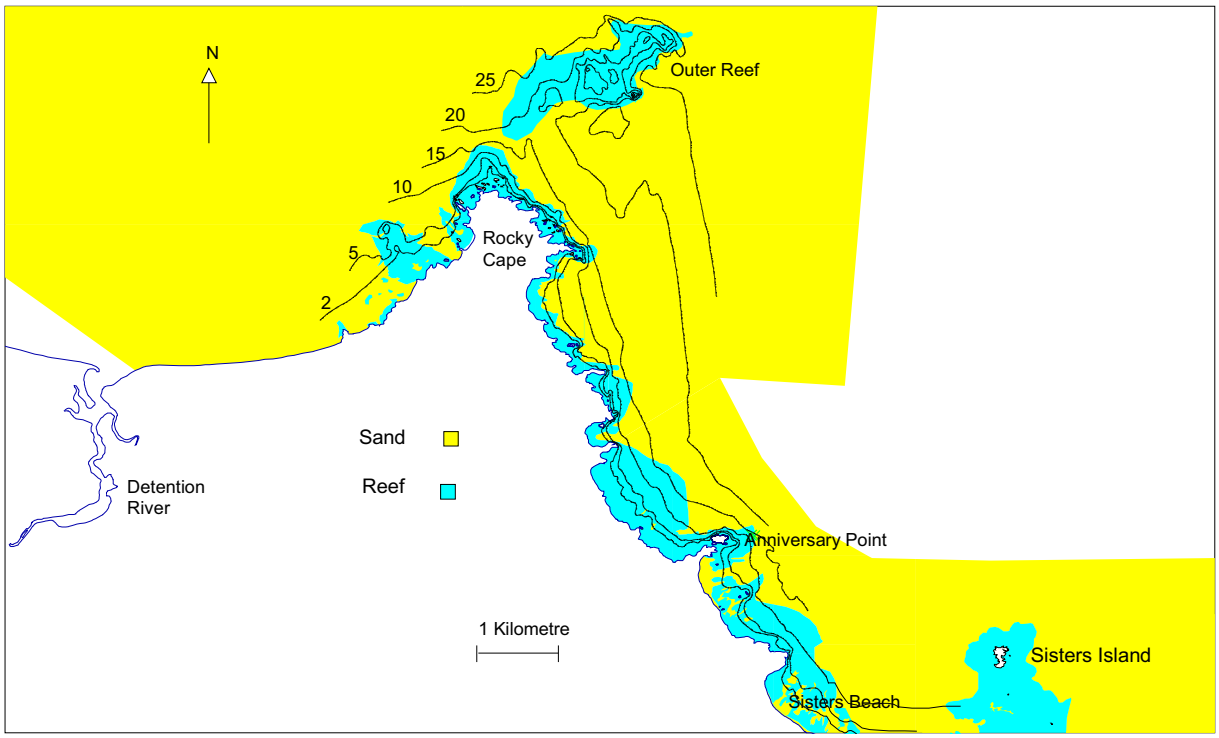

Fig. 18. Broad scale map of marine habitats in the coastal section between Rocky Cape and Sisters Beach on the Tasmanian north-west coast. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

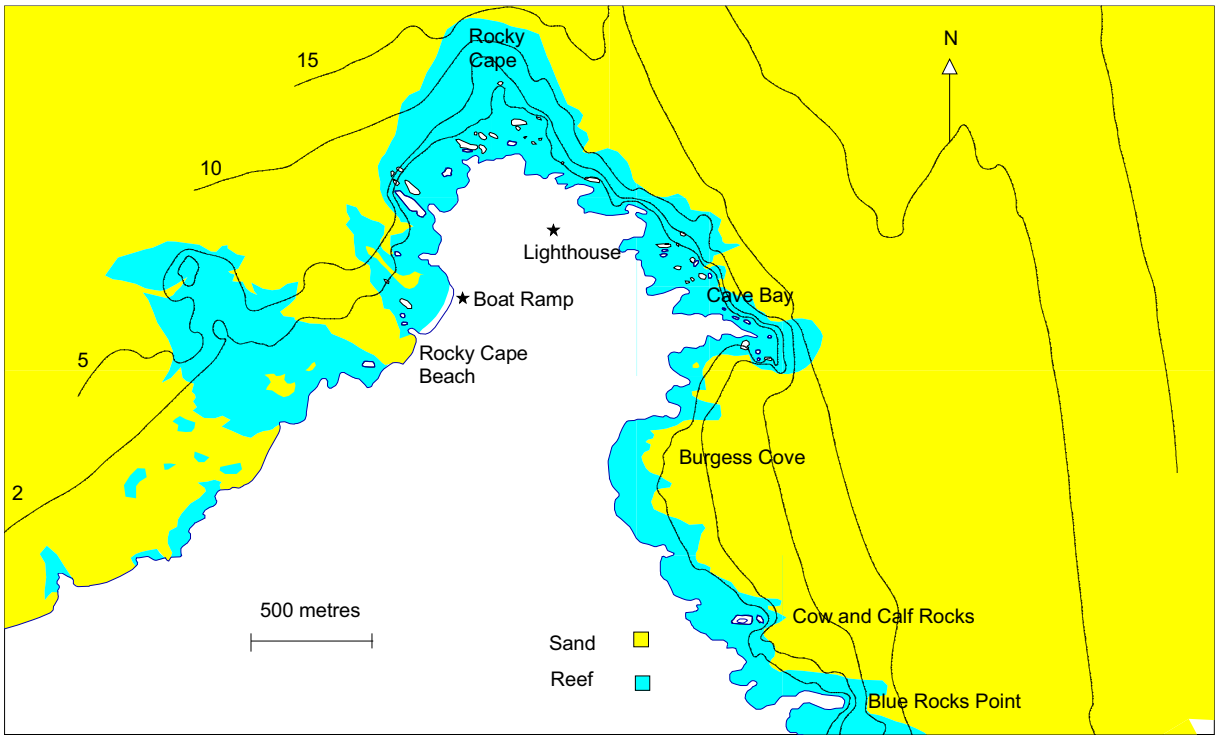

Fig. 19. Marine habitats on the section of coast between Rocky Cape Beach and Blue Rocks Point. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

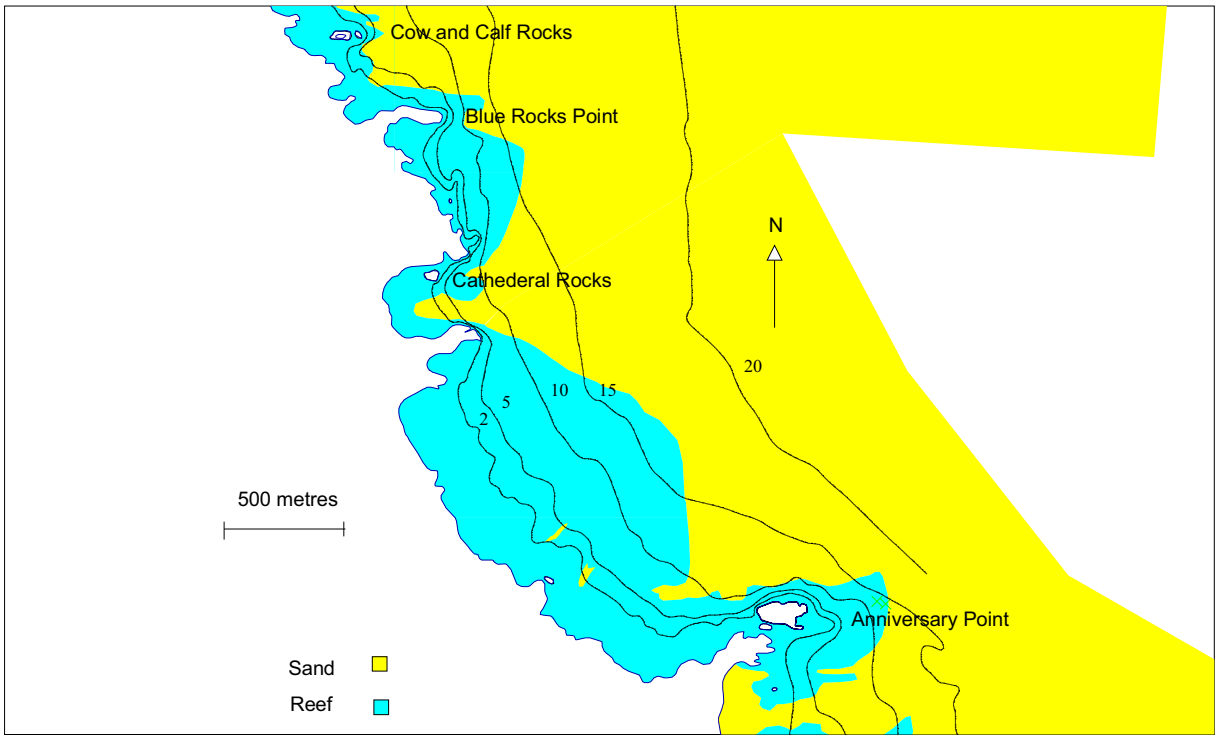

Fig. 20. Marine habitats along the section of coastline between Anniversary Point and Cow and Calf Rocks. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

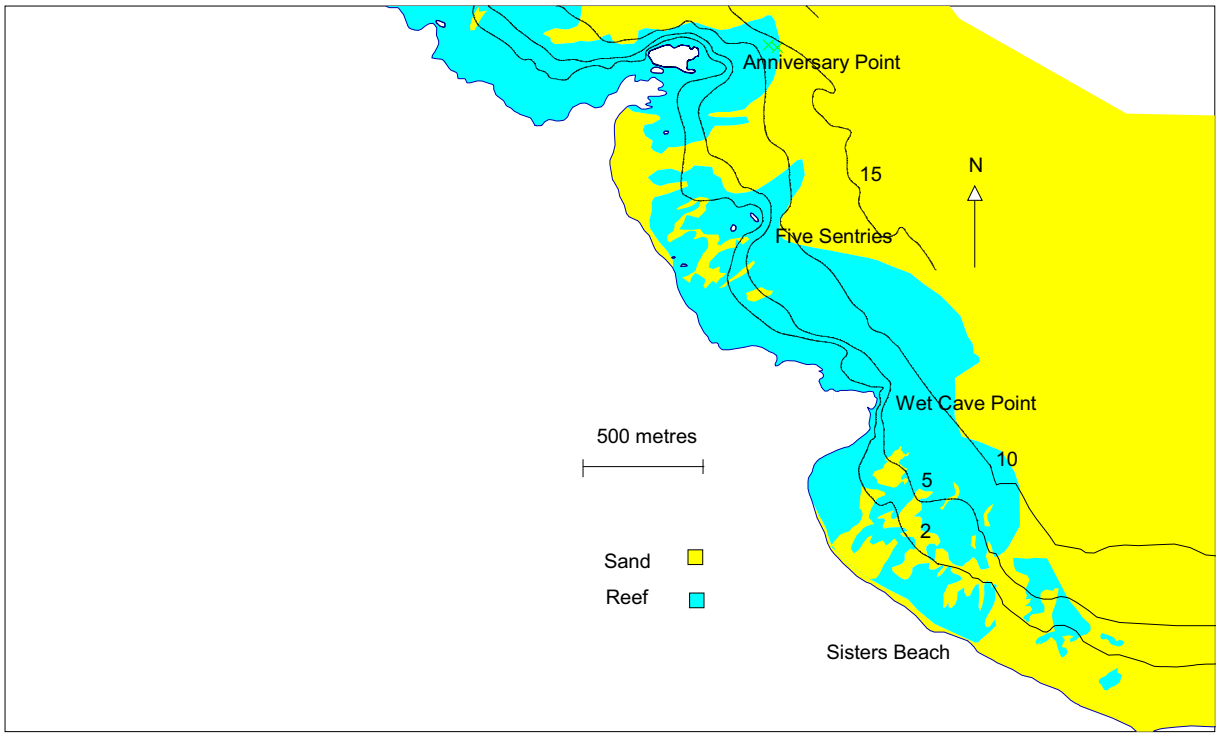

Fig. 21. Detailed habitat map of the coastal section between Anniversary Point and Sisters Beach. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

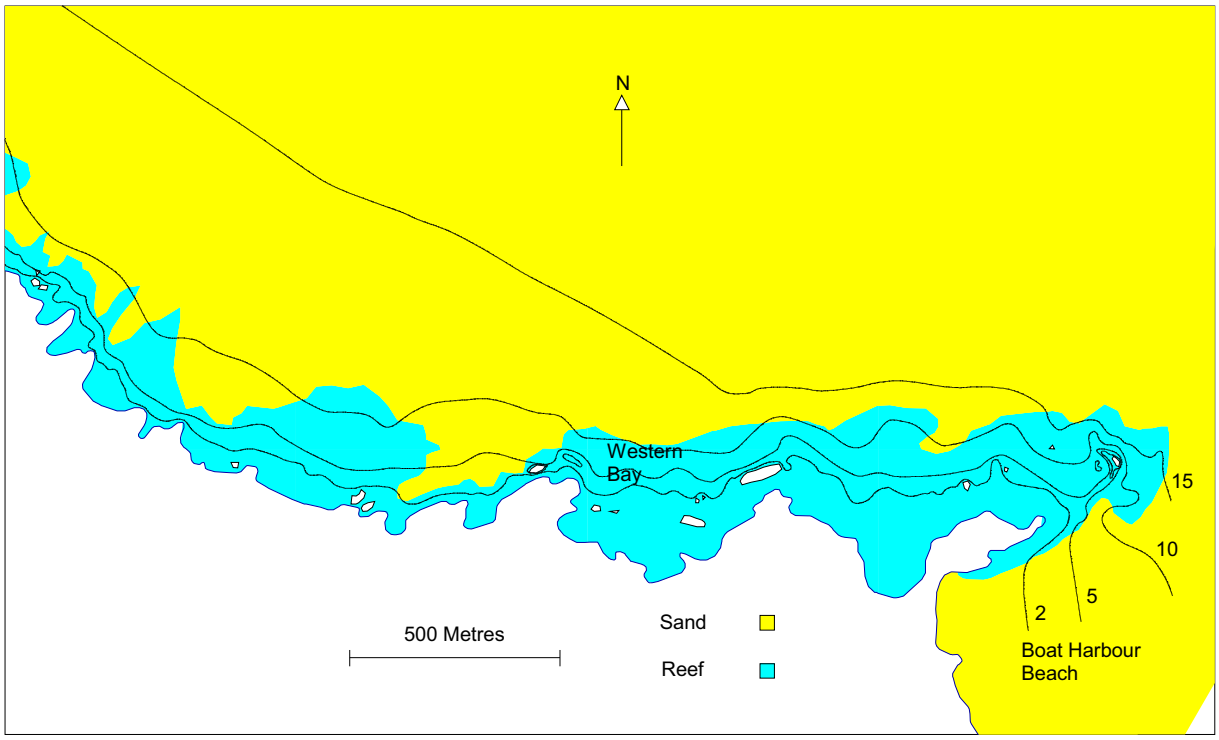

Fig. 22. Marine habitats in the vicinity of Boat Harbour Beach and Western Bay. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

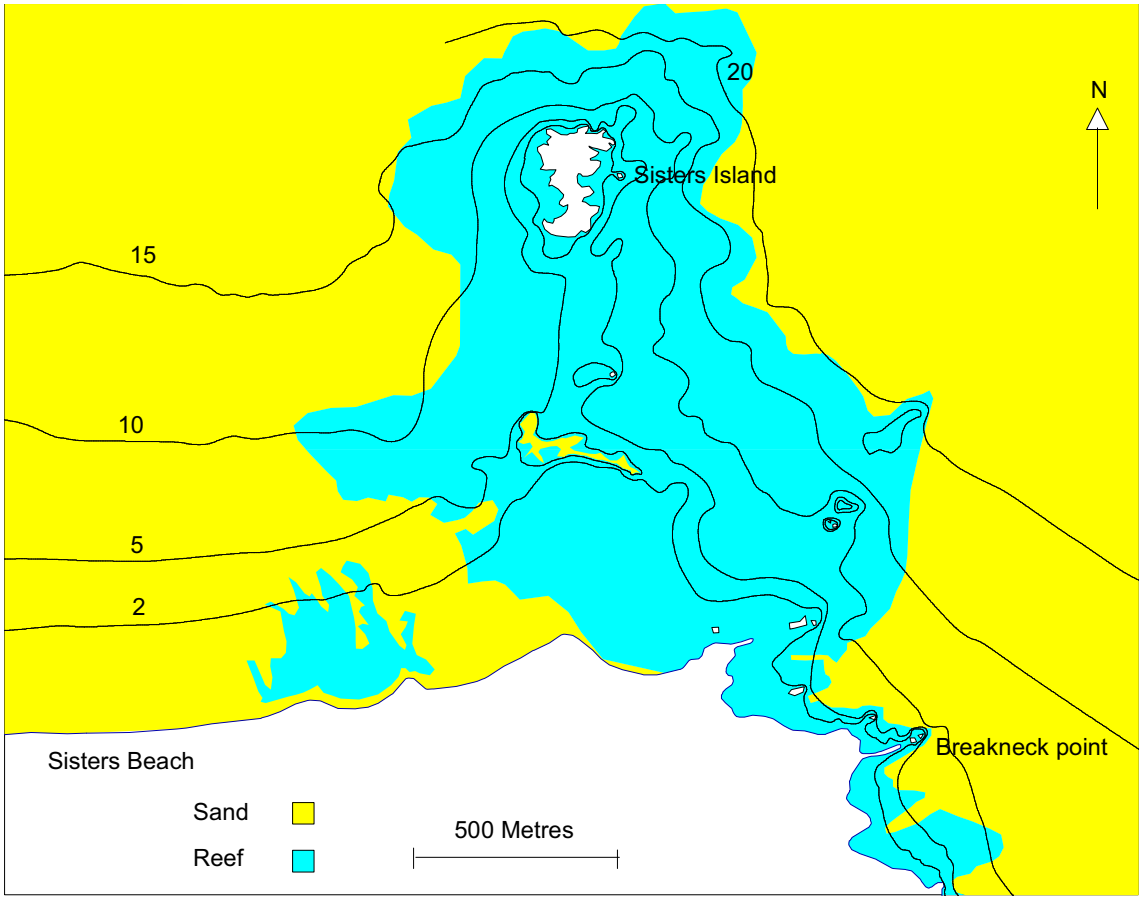

Fig. 23. Detailed marine habitat map of the Sisters Island reef complex. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

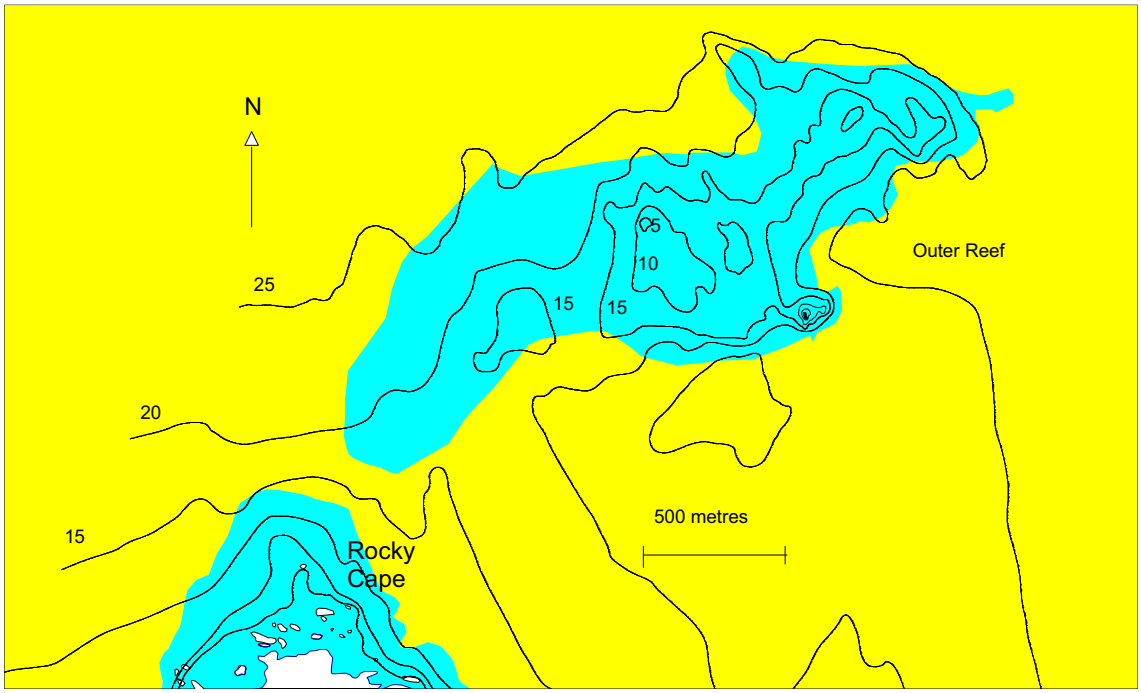

Fig. 24. Marine habitats at Outer Reef and on the northern section of Rocky Cape. Depth contours are given with depth in metres relative to the high tide mark as shown by the coastal outline.

The invertebrate and fish communities in this general area have been described in some detail in Edgar (1981), Barrett and Edgar (1993) and as part of the Iron Baron oil spill assessment (Edgar and Barrett, 1999), and little additional information was contributed from the 10 m depth quantitative surveys conducted during this survey. At all depths and locations the invertebrates *Heliocidaris erythrogramma* and *Haliotis rubra* were particularly common, and invertebrate species richness was high, with the number of invertebrate species encountered at each site reflecting the substantial structural complexity of this region (Table 8). Likewise, the fish community was dominated by *Notolabrus tetricus* (blue-throated wrasse), *Caesioperca rasor* (barber perch), and *Trachinops caudimaculatus* (hulafish) at most locations although at each site a number of other species were usually common, including *Cheilodactylus nigripes* (magpie perch), *Pictilabrus laticlavius* (senator wrasse) and *Siphonognathus beddomei* (pygmy rock whiting) (Table 9). For quantitative transects, the average number of species encountered per site was 17, a count similar to that found at Waterhouse and substantially higher than that found on the central north coast (average of 10). This difference in species richness appears to be related to differences in the structural complexity of the reefs in these areas with increased structure providing increased habitats and refuges for a larger number of resident individuals and species. Both the Rocky Cape Region and the Waterhouse Region have substantially more physical structure than the low flat reefs found on the central north coast.

3.6.3 Discussion

The section of coastline stretching from Boat Harbour to Rocky Cape has outstanding natural values, and as such is an ideal location for the establishment of a representative MPA in the western section of the Boags Bioregon. It contains a complex reef system with an associated diversity of macroalgal, invertebrate and fish species. These reefs are subject to a wide range of exposures from exposed rocky headlands such as Rocky Cape to sheltered embayments. They are also affected by a variety of tidal current strengths, and are found over a substantial depth range from the rocky coastline to depths below 25 m. In addition, sandy beaches are scattered throughout the region, extending as sandy seabed to depths of approximately 2 m at 2 km offshore. This region contains a number of distinct reef/sand habitat boundaries that break up the coastline into discreet sections that could be used as a basis for establishing a MPA divided into one or two sub-units, giving full protection to sections with the highest conservation values while allowing sustainable fishing practices to continue in the remaining area.

The two best options for a reserve would be to either protect all waters 500 m offshore from the seaward reef edge from Rocky Cape Beach to the western end of Sisters Beach (including Outer Reef) or alternatively protect a similar distance offshore from the eastern end of Sisters Beach to the western end of Boat Harbour Beach (including Sisters Island). Both of these proposals would include a full range of the habitats available within this section of coastline in a simply designed reserve of biologically-meaningful size. However, the Rocky Cape section contains the three regional boat ramps (west Sisters Beach and eastern and western sides of Rocky Cape), while the Sisters Beach to Boat Harbour Beach section has the Boat Harbour Beach township at the eastern end.

The most suitable alternative would be to protect the reef system from the northern tip of Rocky Cape seaward to include Outer Reef with a suitable buffer zone around the reef margin, and eastwards to the eastern side of Anniversary Point, in addition to the waters extending 500m offshore from the seaward extension of reef extending from the eastern end of Sisters Beach to the western shore of Western Bay. This proposal would result in the protection of all habitat types in the region, including the sheltered waters on the eastern shore of Rocky Cape, the exposed shallow and deep offshore reefs in the strong tidal currents and clear offshore waters at Outer Reef, in addition to the mix of moderately-sheltered to exposed coastal habitats within the Sisters Island reef system. Additionally, a range of soft sediment habitats would be protected by this proposal, including deep sediment sponge gardens around Outer Reef, and the sparse *Heterozostera* seagrass beds that are found between Breakneck Point and Western Bay. Both of these proposed areas are at some distance from the most heavily fished sections of this coastline, increasing their acceptability to the local fishing community. As well, both areas have sufficient habitat boundaries within them to protect against excessive loss of mobile species to the adjacent fished areas. A further benefit of protecting the coastal section to the east of Sisters Beach and on the eastern shore of Rocky Cape is that recreational snorkellers and divers can easily access these areas from the shoreline under most weather conditions. This would provide substantial recreational and educational benefits, particularly in the vicinity of Sisters Rocks, an area already popular with the recreational diving community due to the rich fauna found there and the presence of several notable underwater caves.

4. Concluding Discussion

4.1 TFIC/TASFA proposals.

With the exception of the Bathurst Harbour/Bathurst Channel proposal that is already well developed, all of the remaining industry and community proposals have been examined during this survey, with habitats within these areas mapped and biological surveys undertaken where possible. The locations were assessed with respect to their conservation benefits (including regional reserve potential), and their ability to protect resident fish stocks based on the suitability of their proposed sizes and boundaries. The proposal for Binalong Bay was found to offer potential for the enhancement of resident fish stocks given the extent of reef that would be protected, and also to offer some conservation benefits as it would protect a representative section of exposed coastline. If small changes were made to the proposed boundary to incorporate the presence of natural habitat boundaries, the loss of resident species to adjacent fished areas would be reduced, enhancing the conservation and stock enhancement values of this proposal.

The protected area at Low Head is unlikely to offer any enhancement of resident fish stocks at its current small proposed size, as it is smaller than the scale of short-term movements of many of the species it would be intended to protect. However, if the protected area was significantly expanded southwards, it would not only include sufficient reef to offer some local stock enhancement benefits, but would also play a conservation role by protecting deep reef habitats in the Tamar river channel, large *Macrocystis* kelp forests and an extensive area of estuarine seagrass beds.

The Lillico Beach and Three Sisters-Goat Island proposals are quite similar in that they both contain areas of low flat reef and cobble, two habitats typical of the central north coast. The absence of available shelter on these habitat types, in association with the lack of algal cover (due to high sediment loads), limits their ability to support large population of fished species and to enhance stocks of resident fish species. If propagation areas are desired they would be better located in areas with greater structural complexity and cleaner water such as Rocky Cape or Waterhouse. However, while unlikely to be effective in enhancing resident fish stocks, the proposed no-take areas, with expanded boundaries, would make a valuable contribution to conservation in this region by protecting habitats under-represented in regional reserve proposals, and further protecting the penguin population that come ashore to nest in the associated coastal reserves.

4.2 Representative bioregional reserves

The results of research on the existing marine reserves in south-eastern Tasmania have shown that in the absence of fishing within these no-take reserves, a substantial change has occurred in the diversity and abundance of species that are normally removed by current fishing practice (Edgar and Barrett, 1999). These results and others derived from research within the reserves, provide invaluable information for the effective management of fishing practices within this region, an outcome that is in addition to the substantially enhanced recreational and educational opportunities now offered by these areas, and the propagation benefits they might also provide. The establishment of a representative reserve or reserves in the Boags bioregion on the Tasmanian north coast will allow for similar benefits to be obtained on this coastline. The variety of rock types, exposures and coastal topography found along the north coast generates a broad range of habitats that cannot be incorporated in a single reserve area and therefore ideally at least two regional reserves would be established there to provide an adequately representative reserve system encompassing the inshore zone.

The section of coastline between Rocky Cape and Boat Harbour on the north-west coast and that adjacent to Waterhouse Point on the north-east coast have previously been identified as the most suitable locations for such reserves (Barrett and Edgar 1993) due to their outstanding species richness and habitat diversity. Subsequent surveys, including this one, have failed to reveal suitable alternative locations. The results of the habitat mapping, additional biological surveys and boundary suggestions presented in this report will therefore hopefully provide sufficient background information for future discussions on these proposals and to facilitate the establishment of a representative reserve or reserves in this bioregion.

The TFIC/TASFA proposals for marine protected areas have the potential to protect additional habitats not found at Waterhouse or Rocky Cape, including low flat basalt and conglomerate reef, cobble (a common north coast habitat) and the deep river channel and *Macrocystis angustifolia* kelp forests at Low Head. If suitable boundaries are chosen for each of these locations they will together enhance the overall conservation of habitats within the Boags Bioregion of Tasmania's northern coastline.

However, while providing some worthwhile conservation outcomes, these areas can not be considered alternative locations for representative regional reserves as they each only protect a very limited array of habitats and are situated in areas with low species diversity, and in the case of the Three Sisters-Goat Island and Lillico Beach proposals, appear to be substantially impacted by high levels of industrial and river derived sediments.

5. Acknowledgments

Many thanks are due to all those who assisted with the various components of this project. Particularly to Andrew Brown for developing the mapping software, Susan Campbell, Graham Edgar and Sam Ibbott for fieldwork, and the staff of the Parks and Wildlife Service, and Land Information Bureau sections of DPIWE who provided access to coastal maps, aerial photographs, and assistance with GIS-based mapping techniques. Comments on the manuscript were kindly provided by Karen Edyvane, Peter Bosworth, Graham Edgar and Colin Buxton.

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